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Metallurgical & Chemical Engineering

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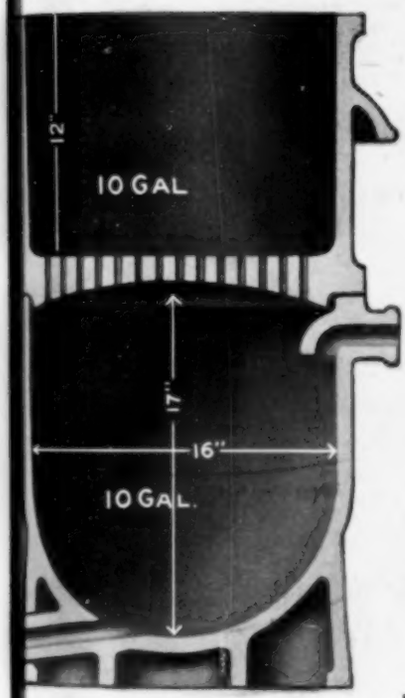

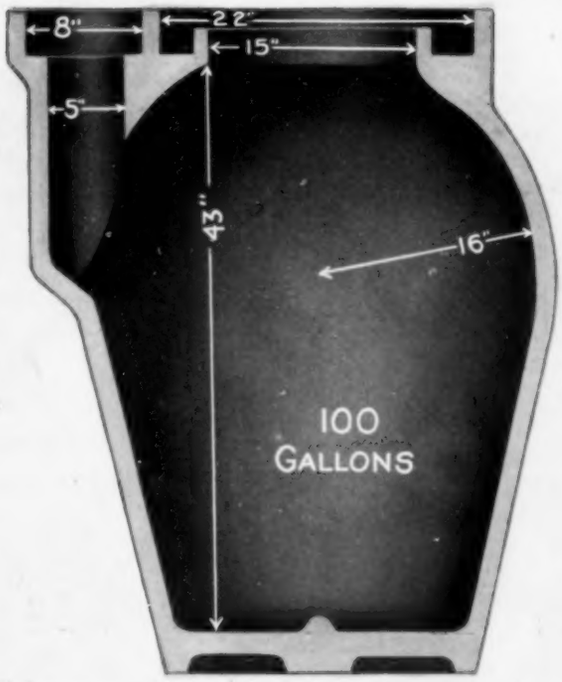

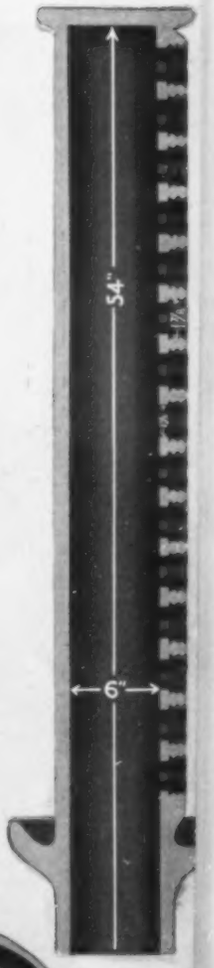

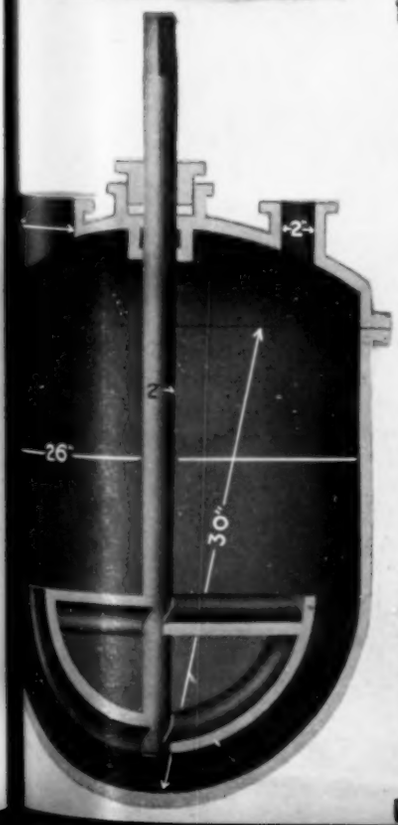

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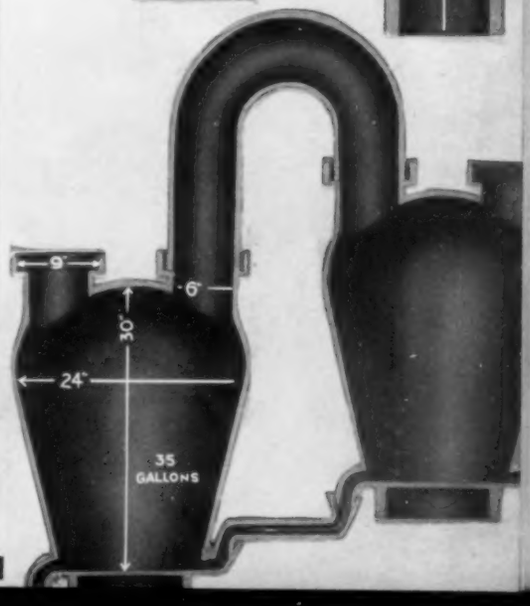

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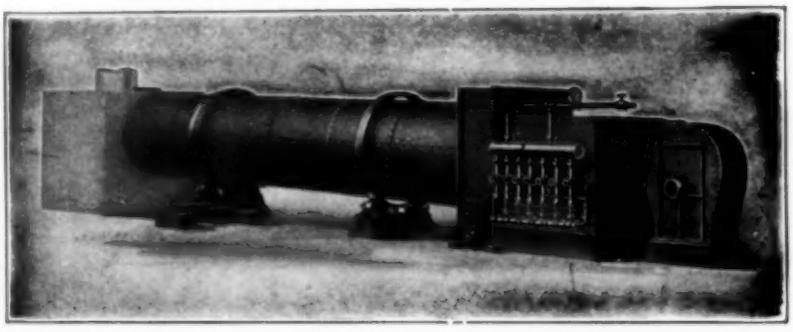

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A Consolidation of
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The McGraw-Hill Consolidation

When in 1909 the McGraw-Hill Book Company was founded as the combination of the book departments of the McGraw Publishing Company and of the Hill Publishing Company, this event faintly foreshadowed the much larger merger which has just taken place of the two publishing companies themselves into the McGraw-Hill Publishing Co., Inc. This, the largest technical publishing company in the world, now publishes Metallurgical & Chemical Engineering, Electrical World, Electric Railway Journal, Engineering Record, Electrical Merchandising, and the Contractor (the old McGraw properties) and Engineering & Mining Journal, Engineering News, American Machinist, Power, and Coal Age (the old Hill properties). Since Engineering News and Engineering Record will be consolidated as Engineering News-Record, this list comprises in the whole ten journals and includes the leading journalistic exponents of the professions of the mining, civil, mechanical, electrical and chemical engineers.

The mere bigness of a commercial undertaking often correctly indicates the measure of its success, because in our modern industrial system bigness usually means the availability and efficient use of mechanical machinery and therefore the multiplication of individual human effort by mechanical means to a hitherto unthinkable extent. Whatever can be done along such lines to facilitate the work of a publishing business, will, as a matter of course, be available to the McGraw-Hill Publishing Co., Inc. But the consolidation would mean little if that was all. What is far more important is the consolidation and co-ordination of brains towards the one goal—to make the different journals of the new company live up to their bigger responsibilities for rendering bigger services to their respective engineering fields. That this can only be done by giving each journal fullest freedom for developing and expressing its own individuality, no one understands better than the creator of the new company, Mr. James H. McGraw.

Patriotism in Chemistry

Things are looking pretty dark. We are living over a volcano and now with the threat of war imminent, patriotic citizens will have some earnest thinking to do before the present storm of passion is over. It will take not only thinking but action, and if we are to come out of our sea of troubles without further disgrace, the action must be unselfish all around. We must stand by the President without thought of party or politics and we must be ready to serve with hearts and heads and hands and fortunes.

We should address ourselves to thoughts of order immediately, so that chaos may be overcome. No mat-

ter how deficient the organization of our government may be, this is not the time to criticise; it is the time to help. The first requirement is chemical and metallurgical organization. This means far more than meetings and resolutions. Among other things it means that chemists who can do productive work in making munitions should be restrained from enlisting to serve with the colors. It is patriotism turned up-side-down for a young man who is familiar, for instance, with nitration processes to march behind the band. The place where he can serve his country most efficiently is right in the works and in the laboratory. We do not mean by this that every drug clerk should be freed from the obligation to go to the front. We mean that research and works chemists and chemical engineers are needed more keenly to-day than ever before to prove themselves competent within their professions for their country's sake. We urge upon every chemical society to get into closer touch with its members to the end that it may be a unit of aid. We cannot organize the government but we can organize the production of what the government needs.

Suppose, as seems likely, the government should take over a number of large plants. Then the only patriotic thing to do is to turn each one over as a producing unit, keyed up to its highest efficiency. The failure to provide that it shall produce its best and its maximum under federal control, would be rank disloyalty.

There is no telling what certain senators and congressmen and government officials will do. It seems useless to guess. But hopeless, dull-eyed, adnoidic stupidity will surely show itself on every hand, and this we must meet with unlimited patience and forbearance. It will be almost unendurable, nevertheless it must not only be endured but met in such a manner as to cause the least loss or friction—and this means also the least offense. The chemists of the United States have suddenly become, in large measure, the trustees of her safety. Let us not fail.

Interesting Pig Iron Statistics

For the first time since 1906, the blast furnace industry had in 1916 an opportunity to operate up to the physical limit. Unfortunately the physical limits included a limitation by the railroads, in that toward the close of the year the furnaces were not fully supplied with coke. The actual production of pig iron, as officially reported, was 39,434,797 tons, including 5323 tons of cold blast charcoal iron and 367,088 tons of warm blast charcoal iron, included that made with charcoal and electricity. Three new furnaces were blown in during the year, two River furnaces of Corrigan, McKinney & Company, May 13 and Dec. 30, respectively, Cambria Steel No. 9 in June, and the United Furnace Company's stack at Canton, Ohio, in November. Thus, although the furnaces lost possibly a quarter million tons of production in the last two months of the year through shortage of coke, the actual capacity of the blast furnaces at the beginning of this year was easily 40,000,000 tons per annum.

As noted, 1906 had been the last year of full production with the available capacity, and the output in that year was 25,307,191 tons, last year's output showing an increase of 56 per cent. The production in the decade ended with 1916 was 271,842,307 tons. There is every reason to believe that the total pig iron production in the United States in all the time prior to the past decade did not exceed 325,000,000 tons, from which it appears that 45.6 per cent of all our pig iron has been made in the past ten years, a very interesting fact, particularly when it is recalled that four of those years were distinctly and unequivocally "bad" years. With the new furnaces being built, several of which are expected to be producing within six months, the prospective capacity is at least 45,000,000 tons.

Of the 17,684,087 tons of basic pig iron produced in 1916, 74.2 per cent was delivered molten, against a proportion of 73.7 per cent in 1915. The production of Bessemer and low phosphorus iron in 1916 was 14,422,457 tons, of which 68.2 per cent was delivered molten, against a proportion of 70.9 per cent in 1915. However, the practice at steel works was probably not materially changed, as the merchant production increased from 871,730 tons in 1915 to 1,976,863 tons in 1916. Nearly all of this was necessarily cast, and indeed a very large tonnage was exported in 1916. The total amount of molten Bessemer and basic iron delivered was 23,082,373 tons, of which a small portion, perhaps a quarter million tons, was delivered molten for the manufacture of ingot molds. The remainder would account for the production of about 30,000,000 tons of ingots, out of a total of somewhat more than 40,000,000 tons produced in the year. The statistics are not yet available.

An interesting fact in connection with the pig iron market of the past few months is that while the total production of pig iron increased by 1 per cent the production of foundry iron decreased by 20 per cent. In common parlance too many men were working the same side of the street. The expectation was that on account of the extreme activity in the steel industry the demand would be for basic rather than foundry iron. The result of men's devices is that foundry iron is selling for at least $2 a ton more in eastern Pennsylvania, and at least $5 a ton more in the valleys, than basic iron.

There was evidently a remarkable revival in the production of Bessemer steel in 1916. The record production occurred in 1906, with 12,275,830 tons of ingots and castings. From 1907 to 1915, inclusive, production averaged 7,200,000 tons, and the Bessemer steel industry seemed clearly decadent. The 1916 production of Bessemer pig iron, however, was 14,422,457 tons, establishing a new record by passing the 1906 record of 13,840,518 tons. Making allowance for the fact that a few hundred thousand tons of the reported output was really low-phosphorus iron, and the further fact that there were exports of perhaps a quarter million tons or more of Bessemer iron in 1916, it would still appear that the production of Bessemer steel closely approached the record of ten years earlier, one that it

had been thought would stand unchallenged. Two Bessemer plants, Duquesne and Homestead, have been abandoned since 1906, while no new ones have been built, a partial exception being that the Youngstown Sheet & Tube Company's Bessemer plant did not start operating until August, 1906. Some capacity has been diverted to the prosecution of the duplex process. As two Bessemer steel plants are now being built, by the National Tube Company and the Mark Manufacturing Company, both in the Chicago district, the production in future is likely to pass the old mark by a wide margin, provided demand for steel is such as to cause all steel productive capacity to be active. In lean years makers having both processes elect to use the open-hearth. In good years they endeavor to secure a premium in the market for open-hearth.

Wages in the Hereafter

At the time of the Napoleonic wars, Lord Wellington, who besides being a man of action was something of a philosopher, said about as follows: "No one can underestimate the unsettling effect of this war on commerce, and on the way men think and act." We think that this remark is as true in the present as it was one hundred years ago. It bears on many things and with special emphasis on the labor situation both now and in the future. What has occurred with regard to labor is so well known as hardly to need repeating. The influx of "war orders" both for raw and finished military material has so stimulated business that the profits on and the prices of all commodities have been raised to abnormal figures. Most metal prices have been at one time many times those of normal times. Demand has exceeded supply. In short it has been "a seller's market." Labor was the last commodity to rise as always happens in a period of inflation, but has recently risen proportionately to the increase in the cost of commodities. Salaries have risen also somewhat and employment has been general. In the chemical industry, young chemists graduating from college or technical school are receiving some $200 a month. It was for them "a sellers' market" and they were not loath to take full advantage of their position.

The thought has been frequently expressed in engineering and business circles whether or no this is not a bad thing for the young men. In the first place, these men are not yet really valuable, for their experience in business and engineering is distinctly theoretical. Especially are they liable to be weak in their conduct toward other men. They may understand all about cement and concrete but not be able to tell how concrete should be mixed as well as an Italian laborer. Much less do they generally understand how to mix with men. There is no school like experience for either wise man or fool, and these boys have had no experience. As a general rule, earning high pay is a dangerous thing for young men, for their youthful energy is easily liable to pass into channels of conceit and egotism. In the case of the naturally far-sighted ones, however, they will gain a clear view of the facts of the case and become more modest and learn how to stand prosperity. We have the testimony of a philosopher as to why the human equation proceeds in exactly the opposite way to the normal and expected way, for Herbert Spencer shows how a beautiful girl may be spoilt by attention and become vain, or, on the other hand, how she may see the insincerity of the flatterers and so become modest and unaffected, vanity being seen and realized.

Hard times, we know, will come. Retrenchment and unemployment will come and then the weeds will be eradicated. As to when and how they will come no one can say, since in abnormal times "one man's guess is as good as another." Surely no prosperity founded on destruction can continue long, and prior to the inevitable subsequent period of re-construction and regeneration there will be a period of liquidation and retrenchment. We will now leave these high-priced young puppies with the hope that they may all become prize-winning bench dogs.

In the period of reform there will be several marked general tendencies. The first is the tendency for the rates of wages to lag behind the prices of commodities in a falling market. High wages will be paid to those men that are kept, but the numbers of men employed will be far less. There will be seen on the streets many anxious and drawn faces of men seeking a job. Now, high wages to efficient men may mean a reduction of costs to meet the falling sales prices, but only to a certain extent. In the next twelve months we shall see society's chronic ailment, the H. C. of L., in an acute form, and its relation to wages is a direct one.

Necessity is the mother of invention, and there will be manifest that "inspiration" and that "perspiration" that Edison says when properly mixed are equivalent to genius. Low margins of prices means brains at work. New processes and new machinery will be used. These processes must use cheaper raw materials, less labor, need less repairs, make more by-products and produce higher-grade materials out of low-priced raw material, with a low capital cost. Interest rates will be dear and new processes must be big earners. Economy and efficiency will be the order of the day. Intelligence and industry will be pass-word of the night. In short, there will be a change, hard as it is to realize it to-day. Incidentally, the application of paternalistic ways will become even more marked than it is to-day and in the future increased number of labor disputes, we will see resulting a paternalism in government and business.

In surveying rather briefly and perhaps somewhat hazily the question of labor rates in the next period of liquidation we are struck forcibly with the thought that a very active and pleasant future awaits members of that class of society who read "Metallurgical and Chemical Engineering." Metals and chemicals are now needed for destruction; they will be needed more in the future for construction. Men will be lacking to do all the work. Brains will be then at a premium in the metal and chemical industry. But just now we can imagine each of our readers quite properly bowing to our argument.

Readers' Views and Comments

Niagara Falls Power Famine

To the Editor of Metallurgical & Chemical Engineering

SIR:—Though Mr. McA. Johnson's, "Fundamental Psychology of the Situation" is theoretically sound, he starts from an incorrect hypothesis and concludes with a futile suggestion.

In the first place it is not correct that if "the Falls, all or in large part, were used for power," there would be only factory buildings to see. It is an engineering and economic impossibility to utilize much more than half the available flow for power purposes. It so happens that that portion of the water which could not be so used is about what would be necessary, if properly diverted and distributed, to maintain a spectacle approximately equivalent to that which we have to-day; and the diversion of the remainder for power purposes would put an end to that steady and rapid erosion at the peak of the Horseshoe Falls which is resulting in an increasing concentration of the flow at this one point to the great detriment of the spectacle. It comes to this that if the matter is properly handled there will continue to be "power for the electrochemical industries and scenery for the bridal couples"; otherwise there will in the course of time be neither.

Mr. Johnson's suggestion, in the second place, takes no account of the unfortunate fact that "the people" do not eat ferrosilicon and do not wear carborundum and are therefore apt to be a little obtuse when the "beauties of electrochemistry" are exhibited in their naked form. The only educative policy which is of the least use is publicity in a popular form properly designed to demonstrate the indispensability of electrochemical products to every-day life, to general industry, to preparedness and so on; a task much greater in magnitude than that suggested by Mr. Johnson, but also, as experience is happily beginning to indicate, not entirely ineffective.

As regards taxation of water power, this is a crime against conservation. Water power is used, not because it is water power, but because it is cheap. Every tax tends to limit the extent of its utilization and to substitute the utilization of those non-replenishable resources, the natural fuels.

F. AUSTIN LIDBURY.

Niagara Falls, N. Y.

Secondary Reactions

To the Editor of Metallurgical & Chemical Engineering

SIR:—In explaining some electrolytic reactions there seems to be a decided difference of opinion as to whether they are all primary, or whether some of them are secondary. In the writer's opinion a primary reaction is one which is produced directly by the current, while a secondary reaction is one which is produced by the chemical inter-reactions of the compounds or elements produced or set free by the electrolysis. This is believed to be the intent of the meaning of those terms. It is, however, not always easy to distinguish definitely between the two.

The writer believes no one will contest his statement that any reactions which do not take place exactly simultaneously with the passage of the current and in proportion to it, as also those that continue after the current ceases, are unquestionably secondary. This eliminates some reactions from discussion, but it is not a definition applying to all, as there may still be other kinds of secondary reactions.

To say that the current separates sulphuric acid into H_2 and SO_4 and that the reaction of the latter radical at the platinum anode combining with H_2 from the water and setting free oxygen, is a secondary reaction, would probably not find general acceptance, as SO_4 does not exist by itself as a molecule, and it would hardly seem rational to say that the electrolytic process was completed until two new, complete, chemical compounds, or free elements, had been produced.

There are probably but few if any chemical changes which do not involve some exchange or transformation of energy, they being either exothermic or endothermic. Hence it seems to the writer that the seat of this energy forms perhaps the best method of distinguishing between primary and secondary reactions, a primary reaction being the one whose energy appears in the electric circuit, while a secondary reaction is one the energy of which does not appear in the electric circuit. If, for instance, zinc is deposited on to a platinum cathode the energy of its reduction must, of course, come from the electric circuit, while when it is subsequently or even simultaneously dissolved by the acid present the energy involved in dissolving it surely does not appear in the electric circuit, and is therefore secondary.

A discussion of this subject of the definite distinction between primary and secondary reactions in this journal might lead to some interesting and useful results.

CARL HERING.

Philadelphia, Pa.

Rapid Analysis of Journal Bearing Linings and Babbitt Metal

To the Editor of Metallurgical & Chemical Engineering

SIR:—The chemist oftentimes is called upon for a rapid analysis of journal bearing linings and babbitt metal, and unless he has had considerable experience in the determination of lead, tin, and antimony in the presence of one another, the analysis becomes somewhat difficult.

The following simplified methods of analysis have been found to be very rapid and accurate. They are modified and simplified compilations of various methods now in use.

METHODS OF ANALYSIS OF JOURNAL BEARING LININGS AND BABBITT METAL

Method for Tin.—Dissolve 1 gram of filings in 20 c.c. of concentrated hydrochloric acid, adding a few drops of nitric acid from time to time until fully dissolved. Concentrate about one-half, add 10 c.c. more of hydrochloric acid and again boil until all nitric acid has been driven off. Add 20 c.c. of concentrated hydrochloric acid, 100 c.c. of water and 2 steel nails. Boil for 25 minutes, cool rapidly with exclusion of air as much as possible, and filter into a 400 c.c. Erlenmeyer flask, wash with cold water, adding 25 c.c. of hydrochloric acid from time to time to the filtrate. Dilute to about 200 c.c. and titrate with N/10 iodine solution using starch as an indicator.

Standardization of N/10 iodine: 12.65 grams I per liter and 30 grams KI; 1 c.c. = 0.01265 gram I approximately; 0.5 gram C.P. tin is dissolved in 20 c.c. of hydrochloric acid, using as little nitric acid as possible. Run almost to dryness and add 10 c.c. concen-

trated hydrochloric acid. Repeat and take up with 10 c.c. of hydrochloric acid and make up to 500 c.c. in a graduated flask.

Use 100 c.c. of this solution to standardize the iodine, adding 25 c.c. hydrochloric acid, two nails, and proceeding exactly as in the above.

Method for Antimony.—One gram of the filings is transferred to a 400 c.c. Erlenmeyer flask; 15 c.c. of concentrated sulphuric acid and 2 grams K_2SO_4 are added and the flask heated on the hot plate until all is dissolved. This is generally accomplished in about thirty minutes from the time fumes of sulphur trioxide begin to be given off. The residue should be white. Seventy-five c.c. of cold water is added after the contents of the flask are thoroughly cooled; 10 c.c. of hydrochloric acid are now added and the solution boiled for exactly twelve minutes. It is then removed from the hot plate and made up to about 200 c.c. with cold water and titrated with standard N/10 potassium permanganate. Standardization of the N/10 potassium permanganate is carried out as follows: To 0.2 gram of C.P. antimony add 15 c.c. concentrated sulphuric acid, heat on a hot plate until solution is complete, cool thoroughly, add 75 c.c. water and 10 c.c. hydrochloric acid and boil for twelve minutes. Make up to about 200 c.c. with cold water and titrate against the permanganate. From this can be calculated the exact strength of the permanganate in terms of antimony.

Method for Lead.—After the antimony has been titrated, boil for about ten minutes in order to remove all the permanganate, cool and filter off the lead sulphate, washing with 1 to 10 sulphuric acid. Dissolve the precipitate with ammonium acetate and acetic acid and precipitate the lead with a 10 per cent solution of potassium bichromate. Let stand on a steam bath until the precipitate is all settled. Filter on a tared Gooch crucible.

Wash with 3 per cent acetic acid. Dry in the air oven at 100 deg. C. and weigh as lead chromate. Calculate the lead.

Notes.—Determine Sb and Sn on same sample by first titrating Sb, then reducing with iron nails. Filter and titrate Sn.

For small amounts of copper, also Sb, Sn and Pb, a 1 or 2 gram sample is dissolved in aqua regia. After solution add tartaric acid (10 grams) and neutralize with 20 per cent NaOH. Then add 20 c.c. alkaline tartrate, heat and add 30 c.c. sugar. Proceed with CuO in regular way.

For Lead in Large Amounts.—A 0.2000-gram sample is dissolved in HCl with addition of $KClO_3$. Cool, add 10 c.c. H_2SO_4 conc. and evaporate to fumes of SO_3. Weigh $PbSO_4$, and to 100 per cent $PbSO_4$ add 0.20 per cent for solubility.

EDWARD J. KOET.

Goodyear Tire & Rubber Co.,
Akron, Ohio.

The Recovery of Benzol from Gas

To the Editor of Metallurgical & Chemical Engineering

SIR:—In Table II of my paper on the Recovery of Benzol from Gas (page 137 of your issue of Feb. 1, 1917) the following minor corrections should be made:

Vapor pressure of toluene at 30 deg. C. should read 37.46 instead of 37.45.

Kg. per cbm. vapor (0 deg. C. 750 mm.) should read kg. per cbm. vapor (0 deg. C. 760 mm.).

Reference 21 should read "Calculated from 10, 17, 19, 20, 27, 28, 2, 3, 5, 8," instead of "Calculated from 10, 18, 19, 20, 27, 28, 2, 3, 5, 8."

F. W. SPERR, JR.

Pittsburgh, Pa.

Coming Meetings and Events

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Individual Effort Versus Corporate Effort*

By J. R. Finlay

The underlying impulse of modern life is the use of mechanical energy to multiply human energy; this brings with it an enormous increase of co-operative or corporate effort; this is changing profoundly our habits of living and making a living, as shown by the growth of immense cities and the employment of large armies of men by single industrial enterprises; it is also affecting our ideas of government, of polity, and of social intercourse.

Now this society has made a great point in giving a medal each year to signalize its appreciation of some individual who has distinguished himself by advancing the arts connected with mining. I expected during the year 1916 to take part, as president of this society, in some ceremonies appropriate to giving such a medal to Professor James F. Kemp for distinguished services in the science of economic geology. Tonight we shall announce the award of the medal to Mr. E. P. Mathewson for distinguishing himself in the art of metallurgy. It would appear from this that the individual still counts for something in our opinion. It also appears that the substitution of corporate effort for individual effort does not destroy the individual: for otherwise we should be giving our medals to corporations.

Now the subject is not so easily dismissed. We have traveled a long way in the direction of substituting the factory for the handicraft. An unskilled boy with a machine, for instance, may turn out as many horseshoe nails as a hundred blacksmiths. Are we not, after all, bringing forward only an occasional man who can perfect a machine and by the same action condemning to a life of hopeless automatism the thousands of men who are to run that machine? This is the view that millions of people have taken, or think they have taken, and who in taking it look with displeasure upon the growth of modern industrialism.

I have been revolving this question in my mind for the past two years and it seems to me I am warranted in expressing the belief that our modern life does not tend to destroy individuality. In fact, the question of human quality seems to be more and more important. I think we mining people have been passing through a period during which we have laid too much stress on natural factors and on technical processes. We are working out of that. Our more experienced men now realize fully and enthusiastically, not as a poetic fancy, but as a practical fact, that the "highest study of man-

*Presidential address before the Mining and Metallurgical Society of America. Very slightly abstracted.

kind is man." To develop a good human specimen, a man or a woman with a balance of good qualities, rises far above any technical subject. The formidable animal is not the product of any system. He is not made by technical training. Technical training is only a tool that he uses. Gold is of no value in itself; its sole value lies in a certain appeal it has made to the human imagination. We have often deluded ourselves into thinking that we are working for things, when in reality we are working to satisfy human wants. A house is of no value unless somebody lives in it, clothes are of no value unless people wear them. We don't dig diamonds for diamonds; we dig to ornament our women!

During the past year or two I have visited and studied in one way or another a good many industrial concerns and I have come to the conclusion that corporate effort is not a substitute for individual effort, but is founded upon individual effort; it can be no better than the materials it is made of. A business may run along all right with a poor or mediocre personnel, just as a house may stand all right and look all right if built of poor materials, but neither can stand a critical test.

The question is, does the training and discipline imposed upon men who must become cogs in great industrial organizations rob them of individual initiative? This is a question really as to the nature of discipline.

On this point, one of the best things I have ever seen was a speech of Mr. Percy Haughton, chief coach of the Harvard football team. After describing how the problem of winning a game was one of team-play by which eleven men might act as one, Mr. Haughton says that to obtain this result careful discipline is necessary, and this discipline can be divided into three elements—physical, moral and mental. Physical training is a mere matter of proper exercise for the muscles and proper care of the body; moral training the preparation of a willingness to do the right thing in the common interest. Mental discipline really includes the others, but relates especially to the development of those perceptions and discriminations which guide an intelligent man. These have to be trained with especial care. The football player is taught to do the obvious and recurrent acts of the game and to obey orders relating to them with the greatest possible precision and dispatch, as nearly as possible without thinking that is, automatically. Does this destroy initiative? No! is Mr. Haughton's emphatic answer, quite the contrary. It is only the most intelligent who can acquire in the highest degree the power to respond to suggestion and to distinguish between an act of routine and a situation requiring initiative. By this test many a fine physical specimen is driven from the team by apparently inferior men. It has been proved times without number that eleven powerful muscular systems operating incoherently are no match for eleven men of average physique whose actions are intelligently co-ordinated. It is not a question merely of willingness to obey orders; it is more apt to be a question of ability to execute orders. When these men have laid a broad foundation of skill in performing those acts which can be formalized, that is, which are so recurrent that they can be reduced to routine, they are able to recognize the situation which is not routine. In other words he is then able to use initiative intelligently, and not till then. "Proper discipline," said a German friend of mine who expressed himself somewhat like an Irishman, "destroys initiative only in those who have no initiative to destroy."

It is clear to me that the same principles apply to industry as to a football team or to an army. The effective employee decidedly must have other qualities besides submissiveness. The effective manager will never forget this. He recognizes that orders can be obeyed effectively and promptly only by intelligent men who can see value in swift and sure performance. Such men show ability in discarding the stupid inutilities of custom and substituting the ordered performance of necessary acts. Many of us imagine that we spend all our time exercising initiative, that we do things through a constant choice of the best thing to do. Nothing is farther from the truth. We spend most of our time, nearly all of it, doing things automatically. We eat and dress after manners developed by long custom. Our own people are only just learning to make a regular custom of washing. We all believe we are intelligent men, capable of initiative, but which of us would dress in Chinese costume and go out on the streets without excitement? We know perfectly well that Chinese clothes are just as good as our own in every respect; why not wear them? Simply because we are accustomed to dress in a certain way, automatically adjusting our minds to follow a system that nobody questions, limiting our liberty of selection to a very narrow range; the wearing of a totally different style requires a new adjustment. We are not interested in clothes and have no initiative about matters of dress. It is only occasionally that we perform an act on our own independent judgment. When you come to think of it, what chance would a man have of selecting the best possible mode of dressing the first time he thought of the subject?

The sound principle of corporate efficiency is expressed by the old saying that "two heads are better than one." How much truer that a thousand or ten thousand heads are better than one? That co-ordinated use of brains results in enormous power and explains the "industrial miracles" that we talk of. It is the true and only explanation of real efficiency.

Any one who thinks this is merely an academic conclusion deceives himself, for the direction of corporate effort is the supreme practical problem of our country and time. It is true, I suppose, that many people go through their business lives successfully without giving any profound attention to the principles which actuate them, but many such would be utterly surprised to find out how far they fall short of good management. Broadly speaking, we find two conceptions of corporate management, the first, and perhaps the most common, being that the main body of employees has no business except to obey and that their activities can all be regulated by orders given in detail by a few select individuals at the top. The watchword of discipline, according to this scheme, is "obey orders if you break owners." The motive is a superficial worship of detail for its own sake. Devotees of detail always find that their employees are not prepared to understand their plans in all their exactitude and promptly jump to the conclusion that the average man cannot be trusted to do anything except under constant supervision, and that the best and highest service the great mass of men can render is that of unquestioning and unthinking subservience. Their idea of organization is the relationship of master and slave. The only ability they wish to recognize is their own ability.

This is poor management. The history of nations proves that! There is no strength in a body politic consisting of many slaves and a few masters. In industry, this theory of management can never produce anything above mediocrity and always ranges down from that to sheer failure.

Real organization depends on what some English philosopher has called "enlightened selfishness." By this plan a leader represents the common purpose, say, of the hundred best men to be had for a given work, and has their backing. That is very different from having a hundred men on whom he merely imposes his will. I suppose people work generally either for money

or for distinction. Each man has a selfish desire to obtain one or the other. Unenlightened selfishness leads a man to wish to be prominent by preventing others from doing things in his stead, or to be rich merely by comparison with others who have nothing. Enlightened selfishness prefers to get success out of the success of others, recognizing that one might be richer by letting others get rich and more distinguished if others help him do things and thereby gain distinction, too. I have seen examples of both attitudes, and have been astonished to find that men at the head of companies wanted no better reason for doing a thing except to have their way and who really cared for no result from the efforts of large numbers of people except to maintain their own position. A man with enough force of will often is able to do this for a long time, but he is weighted with a barren purpose which leads nowhere. Such a man will deliberately choose subordinates of inferior caliber merely because he is sure to dominate them. You all know that it is a commonplace that you mustn't get too good a man for a job! It is dangerous to get too many good men around for fear some one will turn up better than yourself and get your place!

Well, fear of good men is a sure sign of mediocrity or worse. The real leader thinks of nothing so much as to get the very best men that can be had. He is on the lookout for them everywhere, especially among his own employees, realizing fully that work is not done by muscle but by brains and that the more he makes use of the mentality and initiative of all the men the greater his output will be.

How is this done? By interesting the men, appealing to the self-interest and making it worth their while to work for results. I can give you a hint of how it is done by imagining a case; no, not imagining, for it happens every day. Suppose a man is driving a drift in a mine and suppose you approach him with this kind of a proposition:

"You are driving this drift for $10 a foot; that's what it costs. We are well enough satisfied with it, but how would it strike you to see if you could figure out some way of doing it cheaper? If you do it for less than $10 we will split the profit with you."

The miner goes home and tells his wife about it. "Don't do that, John," she will say, "that's only a scheme to get more work out of you. You are doing enough now."

Our man thinks that's about it, and decides to refuse the offer. The incident is ended apparently.

But likely as not it is not ended! True, the man has not done anything, but perhaps he has started thinking about his work, instead of politely going through the motions while really thinking about something else. He will not respond to your suggestion, you may be sure, if he suspects you are a designing rascal intending to exploit him; he must have confidence in you. Given that, our man may think up something worth while and, having done so, will overcome the objections of his wife or anybody else and undertake to put his idea in practice. Even if he does not, the interest he takes in the subject puts things forward because it helps stimulate interest on the part of others.

This kind of thing is not technical, it is human leadership. Your man who is able to do this is no more to be turned out of a school by the force of a curriculum than is a poet. That does not argue against education, for even a poet is no better for being an ignoramus; it merely argues for education of the right sort and against trying to educate square pegs to fit round holes.

You hear a great deal about labor troubles. Nine-tenths of them are caused by poor leadership. A strike may be caused by one of two things: either the conditions are so bad, or so irksome, that it inevitably occurs to the men to rebel against them; or some agitator persuades them to rebel. How does the agitator do that? Simply by interesting them more than their employer does. Perhaps life is merely dull and he offers a prospect of excitement and change. If an agitator can make such a proposition stick against the apparent self-interest of the men, I take it that he displays ability and that the employer ought to change places with him. Your real leader will not be satisfied merely to call the agitator an interloping blatherskite behind the men's backs; if that is true he will make them feel it. Your conspicuously successful concerns don't have strikes; there is no money in them for anybody. The Standard Oil Co., berated by outsiders for forty years, always held the loyalty of its employees, and although those men were in plants all over the world there was never a strike until a few months ago. The men who founded and built up that concern were great men, too big to be supplanted by mere agitators, or to try to ignore the genuine interests of their employees. If you will notice the cases where strikes have occurred in successful concerns you will find that the managers of plants where they do occur usually lose their jobs before the thing is finally settled. One of the great forces in human nature is the sporting instinct; man wants to fight somebody and beat him. The battle of industry is just as savage as any other battle and your true leader knows it. It is a mighty poor human atmosphere where the men feel they have nothing better to fight than the clock. They don't stand that long. If they get to killing time that is only a step toward killing men.

The Application of Nitro Aromatics in Explosive Industry

By John R. Mardick

The basis of every kind of explosive made in this country from high-power gelatine dynamite down to low-grade permissible explosives contains nitroglycerine. This is specially true in the case of blasting explosives, or, in fact, all the explosives made for commercial purposes; for instance, explosives used for shattering rock, tearing dirt, and mining coal contain nitroglycerine.

As a result of the large demand for glycerine in the explosive industry the price of this commodity has gone from 12 cents per pound a few years ago up to 60 cents per pound at the present time. There are no indications that these prices would be any less after this war is over. The reason for this high price of glycerine is that the supply has not increased with the demand. As a matter of fact, the fat stock which is the only principal source of glycerine remains either stationary or, if anything at all, it has a tendency to decline.

The glycerine situation is similar to that of hide and leather. There is more demand for hide and leather than the supply of the world can take care of. This situation in hide and leather has given a new start for artificial leather. In the same way as the price of glycerine increases, explosives containing nitroglycerine will command a higher price than ever before.

It has been said that necessity is the mother of invention. The high price of Italian sulphur compelled the sulphuric acid manufacturers to use pyrites. So if we must have explosives we may resort to other raw materials to compete with dynamite made from a high-price glycerine. The price of modern commercial blasting explosives has doubled in the last few years, and there are no indications that with glycerine even at 30 cents per pound the manufacturers will be able to offer low-price explosives, say at 10 or 11 cents per pound.

Fortunately, there are other cheap raw materials from which powerful commercial explosives can be made. I refer to certain nitro-aromatic bodies which are made in this country at present for military purposes, and which have not been compounded as yet into blasting explosives. The sources of aromatic bodies are almost inexhaustible, and the situation is likely to remain so in spite of the fact that large quantities of coal-tar oils will be applied in dyestuff industries in the very near future. To be more specific, toluol, phenol and other similar derivatives from coal tar would be a drag on the market after the war is over. It is not unlikely that toluol will drop to as low a price as 30 cents a gallon. Synthetic phenol will disappear from the market altogether, and the natural carbolic acid will probably bring less than 10 cents a pound. It is easy to see that with such cheap raw materials on hand the problem of manufacturing high explosives at reasonable prices will be readily solved.

It must be admitted that there are some difficulties which must be overcome before it will be possible to engage in the manufacture of commercial explosives having for their base nitro-aromatic bodies such as trinitro-toluol and picric acid. The greatest obstacle to success in this line would be the natural prejudice of the explosive manufacturers themselves against the use and application of aromatic compounds. There are explosive manufacturers in the trade who think that the only successful blasting explosives for all-around purposes are dynamites and those explosives having nitroglycerine as a base. They say that other explosives starting from the aromatic series are either too dangerous or not sensitive enough for commercial uses. They forget the fact that the manufacture and the use of N.G. as explosive was strongly forbidden for some time, until Alfred Nobel overcame all the difficulties, controlled the manufacturing process and the dangers of N.G., and thus laid the foundation of his immense fortune.

No serious efforts have been made in this country to make explosives containing other than N.G. True, there have been spasmodic attempts here and there by amateurs, but they had neither the technical organization nor the necessary capital to push the matter through. With the first difficulty their enthusiasm died away. At the present time there are two firms in this country who make blasting explosives which do not contain N.G. One has nitrostarch for its base and the other chlorates. However, the volume of their business has not assumed such large proportions as to make them a large factor in the explosive business. Seven firms, large and small, make only N.G. explosives and control the entire U. S. market.

Before the war all the principal countries in Europe, including Germany, England, France, Austria, Italy, Belgium and Russia, were making large quantities of explosives from nitro-aromatic compounds, which were known as *safety explosives*, and were very successfully used in all kinds of blasting, mining and quarrying work. Some of these explosives correspond to our *permissible* explosives used in coal mining, where N.G. explosives were excluded on account of its pulverizing effect on coal. It is a fact that nitro-aromatic explosives while somewhat slow in velocity have a better shattering action that N.G. explosives, and are especially suitable in quarrying and coal mining.

It seems to me that this is an opportune time for T.N.T. and picric acid manufacturers to look into this matter from the business and manufacturing standpoints. They have their plants all built up, they have the capital, and after paying for land, machinery, etc., undoubtedly they have made some money. On the other hand, probably, they have got the last of their war orders. What are they going to do with their plants? Some say, "What do I care? I have made some money over all the expenses and can afford to dismantle the plant and sell the land." Others may continue to make a limited quantity of secondary chemicals for dyestuff manufacture, and thus keep up a small business. But there are other important uses for their investment, as we shall see from the following.

According to the report of U. S. Bureau of Mines for the calendar year 1915, there were manufactured in this country:

High explosives (N. G.)	117,907 tons
Permissible explosives (N. G. and ammonia)	13,687 tons
Blasting black powder	98,860 tons

It may be remarked that N.G. forms the basis of all high explosives while the black powder is made up as usual from nitrate of soda, sulphur and charcoal. The same statistics show that the production of black blasting powder is steadily decreasing from 115,000 tons in 1912 to 98,860 tons in 1915. Evidently permissible explosives are making heavy inroads into the blasting-powder business. This is evident from the fact that the manufacture and use of permissible powders have increased correspondingly with the decrease of black blasting powder.

As we see from these quotations, there are good chances to replace blasting powder by permissible explosives made from aromatic bodies, such as T.N.T. and picric acid, which will meet easily the Government requirements much better than N.G. permissible explosives. In making explosives one must not lose sight of the fact that N.G. contains more than sufficient oxygen for its combustion, while the nitro-aromatic bodies, including T.N.T. and picric acid, are deficient in it. In order to produce a complete combustion it is necessary to add oxygen carriers to the aromatic compounds in the shape of nitrates or chlorates, and thus eliminate as much as possible the formation of dangerous gases like carbon monoxide.

The prospective manufacturers of explosives must allow ample time to proceed carefully and slowly in making scientific combinations. First, they ought to adjust and correct their processes in order to produce the highest possible yield in T.N.T. and picric acid, by sacrificing time for more yield and better quality. As they have no rush war orders to fill they can cut down their expenses commensurate with the highest yield. Then they will be in position to compare the cost of production of N.G. at 235 lb., T.N.T. at 215, and picric acid at 190 as yields for 100 lb. of raw material.

The cost of raw materials may be represented as 30, 8 and 4 cents for glycerine, phenol and toluol respectively. Furthermore, in making exact calculations it is perhaps advisable to assume the price of nitric acid to be 5 cents (100 per cent) and that of sulphuric acid (100 per cent) to be 1 cent per pound.

The manufacturing cost of a 40 per cent explosive in normal conditions may be figured out as follows:

Straight Dynamite	Percentage	Cost per Pound	Cost
Nitroglycerine	40	.20	8.00
Wood pulp	15	.01	.15
Sodium nitrate	44	.02¼	.99
Anti acid (carbonate)	1	.01	.01
Labor, power, boxing, etc.	..	..	1.15
Cost per pound of straight 40 per cent dynamite			10.30

Before the war this 40 per cent explosive was manufactured at 8 cents per pound and sold at 10 to 10½ per pound (wholesale). In the same way the cost of other dynamite explosives known in the trade as low-freezing, ammonia, and gelatine dynamites, may be calculated.

Now compare this cost with the same grade (40 per

cent) of safety explosive made from a nitro-aromatic compound:

	Percentage	Cost per Pound	Cost
Nitro-aromatics	25	10	2.50
Combustibles	10	1	.10
"Dope"	64	3	1.92
Anti Acid	1	1	.01
Labor, power, boxing, etc.	..	..	1.50
Cost per pound of 40 per cent new explosive			6.03

As we see from these figures, the cost of aromatic explosives stands out 6 to 10 against N.G. explosives. In other words, there would be a clear margin of 4 cents in favor of aromatic explosives against the same grade of dynamite. The 40 per cent straight dynamite with a manufacturing cost of 10 cents per pound cannot be sold in normal times at less than 14 cents per pound.

Manufacturing cost	10.30
Overhead expenses, selling	2.00
Net profit	1.70
Selling price of 40 per cent straight dynamite	14.00

It is easy to see that aromatic explosives under the same conditions can easily compete against N.G. explosives.

I have tried to point out very briefly the possibilities and the promising future of nitro-aromatic explosives. It will pay for T.N.T. and picric acid manufacturers to make further investigations along these lines before dismantling their plants. On the supposition that aromatic explosives may secure 25 per cent of the explosive business, there would be a volume of new business amounting to 30,000 tons per year, which at a conservative profit of $60 per ton will figure out as $1,800,000 per annum. This certainly is not a neglible business.

Will the T.N.T. and picric acid manufacturers overlook this field of enterprise knocking at their very doors? The proposition from a commercial, economic and hygienic standpoint is a feasible one. They have the capital and the plants to start with. Why not bring together an efficient technical explosive organization and start the ball rolling while there is yet time?

New York City.

Annual Meeting of American Ceramic Society

The annual meeting of the American Ceramic Society was held in New York City Monday, March 5, to Thursday, March 8, with headquarters at the Hotel Astor. The business session was held on Monday morning, followed by the presidential address of LAWRENCE E. BARRINGER of the General Electric Company, Schenectady, N. Y. Sessions for the reading of papers were held at the Astor on Monday afternoon, Tuesday morning and Wednesday morning and afternoon. On Tuesday afternoon a session was held at the Metropolitan Museum, including lectures and an inspection tour. On Thursday an all-day excursion was taken to Perth Amboy, N. J., and vicinity to visit the plants of the Atlantic Terra Cotta Company, Didier-March Company and the Fords Porcelain Works.

A paper on "Humidity: Its Control and Relation to Drying Clay Wares" was read by W. A. DENMEAD of the General Electric Company, Schenectady, N. Y. The subject is an important one, and in discussing the paper President Barringer said that through the study of humidity the General Electric Company has been able to reduce the time of drying from eight to nine weeks to about one week. The Harbison-Walker Refractories Company at Pittsburgh have also greatly reduced the drying time by the study of this subject. He said that the air conditioning manufacturers and engineers are able to furnish apparatus and data on this subject of great value to manufacturers of claywares, and that a greater appreciation of the subject would be found of great benefit.

A paper on "Making Paving Brick from Blast-Furnace Slag" was read by J. B. SHAW of Alfred, N. Y. Mr. Shaw has recently concluded some very successful tests along new lines. The subject has been investigated by nearly every blast furnace plant, in most cases with negative results. Mr. Shaw placed the amount of slag available as 16,000,000 tons, based on a pig iron output of 33,000,000 tons. Two million thousand paving bricks could be produced from this, and still leave 2,000,000 tons of slag for cement manufacture. In 1915 $35 per 1000 was paid for the slag bricks which were made. At present it costs blast furnaces on the average 10 cents per ton to dispose of their slag. Mr. Shaw stated that brick can be successfully made at from $5 to $7 per 1000. He has visited many blast furnaces in the country and found that nearly all of them had done some work on the subject, which had practically all resulted in failure. In tests made at the Birmingham Slag Company's plant at Birmingham, Ala., he found that by making changes in the slag by adding sand, iron oxide, etc., that various kinds of brick could be successfully made. It was found that the slag must be taken molten just as it comes from the furnace and the modifications made then, as it would not be economical to remelt it. American slags run about 12-14 per cent $Al_2O_3 + Fe_2O_3$, while the English slags from which brick are made run 20 per cent and over. Tests were made at the plant of the Bethlehem Steel Company at Sparrows Point, Md., and brick were made from the slag there which were better than the shale brick and equal to the English brick. Efforts were made to obtain patents on the process, but owing to numerous other basic claims this was found to be out of the question. In reply to a question Mr. Shaw said the brick must be annealed out of contact with air or steam. The annealing should be started at almost the softening temperature and held uniform. The brick will not then become brittle. He thinks that any slag can be successfully used.

An interesting illustrated talk on "By-product Coke Oven Construction" was given by R. J. MONTGOMERY of the H. Koppers Company, Pittsburgh, Pa. He said that construction of by-product coke ovens in this country was only limited by the production of high-grade silica brick. For the modern oven 227 different silica shapes and 85 clay shapes are needed. The silica brick manufacturers have so far been slow in taking care of this difficult proposition adequately, and neither they nor the oven builders are satisfied as yet.

Many other interesting papers were read at the meeting, an account of which is reserved for a later issue. One of the features of the last day was Emerson P. Poste's paper on enamel surfaces under the microscope. The whole convention was very well attended and was successful in every respect.

Spring Meeting of American Chemical Society

The spring meeting of the American Chemical Society will be held in Kansas City, Mo., and vicinity from Monday, April 9 to Saturday, April 14. The headquarters will be at the Hotel Muehlebach. A general meeting will be held on Wednesday morning at which addresses will be made by Hon. George H. Edwards, mayor of Kansas City; Dr. Frank Strong, chancellor of University of Kansas and Dr. Julius Stieglitz, president of the A. C. S. A public session will be held on Wednesday afternoon on "Petroleum and Natural Gas," and on Wednesday evening a smoker will be held. The banquet will be held on Thursday evening.

Western Metallurgical Field

Cobalt

Cobalt Alloys with Non-Corrosive Properties.—Bulletin No. 411 of the Canada Department of Mines is Part IV of Researches on Cobalt and Cobalt Alloys, by Dr. HERBERT T. KALMUS and K. B. BLAKE. It is a treatise on non-corrosive alloys containing cobalt and covers 37 pages. The article is profusely illustrated with photomicrographs and curves. It is an elaboration of the same author's paper presented at the last convention of the American Institute of Chemical Engineers (this journal, Jan. 15, p. 82).

The conclusions drawn from preliminary tests were: that additions of nickel or cobalt to American ingot iron proved beneficial as far as non-corrosive properties were concerned with cobalt ranking first. The final conclusions drawn from the work are: that the corrosion in grams per square centimeter per hour of the original surface is a function of the length of exposure. Alloys formed by the small addition of copper, nickel and cobalt (0.25 to 3.0 per cent) to American ingot are more resistant to atmospheric corrosion than the pure iron itself. Alloys made with cobalt (0.25 to 3.0 per cent) from American ingot iron with very little, if any, carbon indicate, that the corrosion is not a simple function of the percentage of cobalt content. Alloys containing 3 per cent cobalt showed a corrosion amounting to 75 per cent of that obtained with alloys containing 0.5 per cent cobalt. Alloys with from 0.25 per cent to 3.0 per cent cobalt and low in carbon show atmospheric corrosion to the extent of 50 to 75 per cent of that of pure American ingot iron. Very little difference in the corrosive action could be observed whether cobalt or nickel was used. The oxide coatings formed during the progress of corrosion on the surfaces of the materials indicated that those formed when cobalt was used were darker in color, denser and more tenacious than those formed by the other alloys. However, though this coating with cobalt had a better appearance, the protective quality was not in favor of cobalt. An addition of copper (0.25 to 0.75 per cent) seemed to reduce the atmospheric corrosion of American ingot iron. The authors are conducting further experiments along these lines which will be published in a later paper.

Flotation

The New Trend in Flotation Practice.—It is worthy of notice, that not all the companies using the flotation process are going to pay back and future royalties to the Minerals Separation, Ltd., without another endeavor to prove, that the process may be used without infringing on the patents of said corporation. The general trend of the newer investigations is along the lines of using more than 1 per cent oil and circulating same in the process. The idea may be explained as follows:

The pulp from the ball mill enters a sludge tank. From this tank the pulp goes to an emulsifier from where it enters the flotation cells. The froth collected in the "spitz" of the cells is filtered through a revolving filter of the Oliver type, from where the partly dried concentrates go to a bin. The water plus oil from the filter press goes back to the sludge tank from where it again enters the system. The tailings from the flotation cells are conducted to Dorr thickeners, where they are partly dewatered; the water plus oil obtained from this operation also is returned to the sludge tank to be reused in the system. The tails from the thickener go to waste.

The idea as such is very clever. It is the intention of the companies working along these lines always to replace the oil used up and to maintain the flow of oil in the circuit above 1 per cent of the ore treated. Unconsciously, one might say, is this scheme "fool-proof"? Would it be possible to show that the oil used during the operation, allowing a certain percentage for mechanical loss, which is actually doing the work is still less than 1 per cent.

The Flotation of Tungsten Ores.—Some experimental work has been done on the flotation of ferberite ores of the Nederland District of Colorado. The results showed that these tungsten ores could be concentrated by means of flotation as far as laboratory tests were concerned. On the other hand, practical tests have shown that the flotation of the tungsten values from these ores was uneconomical. The reasons given for the latter statement are as follows: The mill run as a rule is not uniform enough as regards WO_3 content. The presence of iron in some of the ores destroys the action of the oil mixtures used. And finally the presence of "horn rock," a jaspar wherein the coloring matter is tungsten instead of iron, is detrimental to the action of the oil.

The Flotation of Molybdenite.—In the Summary Report of the Canadian Department of Mines for the year 1915, which has recently appeared, several pages are taken up with results and other data regarding the flotation of molybdenite. The tests made were laboratory tests and in general were conducted as follows: the ore was crushed in jaw crushers to about 1 in. size. This material was then elevated to an ore bin from where it passed through rolls set at ½ in. From the rolls the ore passed to Ferraris screens fitted with ⅛ and 1/16 in. openings. On these screens the flaky material was picked out and kept separately. The final size ready for the flotation ranged between 16 and 20 mesh. This product was then fed to a Wood flotation machine and floated with water. As the tests were run on a comparatively small scale the results obtained indicated large percentage losses, which it is believed would not be the case if practised on a large scale. The following general conclusions were reached: Crushing in stages is advisable. The fines should not be rejected, as this practice would involve a considerable loss. Hand sorting should be resorted to, as a large amount of flake can be obtained in this way. After hand picking the ore should be crushed from 16 to 20 mesh and sized for flotation by water. The combined hand picking and flotation should give a recovery of 80 to 85 per cent molybdenite in practice.

Company Reports

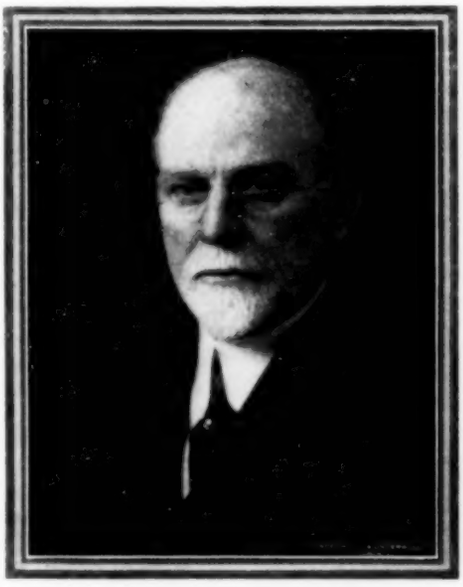
The Twenty-third Annual Report of the Portland Gold Mining Co.—During the past year 394,788 crude tons of ore and waste were mined and handled by the company operations. After sorting, this yielded 63,457 tons of shipping ore which gave a gross return of $1,540,462.49 or $24.275 per ton. The ore milled at the Victor plant showed a decrease in value of 39 cents per ton as compared with last year, or 13 per cent for the year. The gross value of ore mined and shipped was $2,236,842.46. The gross values recovered at the Victor mills amounted to $612,576.89. The net cost of mining and milling amounted to $2,102,715.92. The gross profit from operation is therefore $746,703.43. To this latter figure are added $22,106.41 for revenues from all other sources, which bring the net profits of the company for the past year as far as mining and milling operations are concerned to $768,809.84.

American Indigo Now Produced.—The Dow Chemical Company, Midland, Mich., has begun the production of indigo in spite of the unfavorable tariff conditions which have held it up for considerable time. The output is 1000 lb. per day of 20 per cent paste.

The Evolution of the McGraw-Hill Publishing Co., Inc.

Through the consolidation, announced on the first editorial page of this issue, of the McGraw Publishing Company, Inc., and the Hill Publishing Company into the McGraw-Hill Publishing Company, Inc., Mr. James H. McGraw, the president of the new company, becomes the pre-eminent figure and predominant influence in American technical journalism. A brief sketch of his life and work and of the evolution of the company which he heads is of particular interest at this time.

James H. McGraw was born in Panama, Chautauqua County, N. Y., in 1860 and graduated in 1884 from the Fredonia Normal School. After teaching school for a few years, he commenced his life as a publisher with the American Railway Publishing Company of New York, then owner of the "Street Railway Journal" and two other papers. Shortly after the dissolution of this company in 1888, Mr. McGraw acquired the "Street Railway Journal."



JAMES H. McGRAW

His acquisition of this property merely started him upon his career as a publisher. The rapid development of electric traction and the consequent obsolescence of the horse car placed him in a strategic position. He had a great influence in the field, and he used it always for the upbuilding of the industry. In fact, it is generally recognized that no one has done so much for the electric railway business as he. He worked not only through his paper, which later was renamed the "Electric Railway Journal," but also through the American Electric Railway Association, in whose work he has taken an active part.

With the growth of electric traction, other developments occurred. Great industries were springing up for the manufacture of electric equipment of all sorts. To so keen an observer as Mr. McGraw, these beginnings of an electrical industry, which was soon to become colossal in its proportions, were significant. Again his vision pictured an immense field for a technical journal. With this conception in mind, he purchased in 1896 "Electrical Industries," which he renamed the "American Electrician," a monthly periodical devoted to electrical and mechanical engineering. Three years later, in 1899, he acquired the two leading electrical journals—the "Electrical World" and the "Electrical Engineer," both of New York. These, with the "American Electrician," were consolidated into one publication, the "Electrical World," now the leading journal of the electrical industry.

To control these properties the McGraw Publishing Company was incorporated in 1899, with Mr. McGraw as president and controlling stockholder. He struck out into new territory in 1902, entering not only into the civil engineering and contracting field by the acquisition of the "Engineering Record," but giving his aid and influence in the autumn of the same year to the formation of the Electrochemical Publishing Company for the purpose of publishing a new monthly, "Electrochemical Industry," as the journalistic exponent of the then young art and science of electrochemistry. In 1905 the scope and name of the paper were enlarged to "Electrochemical and Metallurgical Industry." Again in 1910 the scope was broadened and the name changed to "Metallurgical & Chemical Engineering." In 1912 the entire stock of the Electrochemical Publishing Company was acquired by the McGraw Publishing Company. Since September, 1915, "Metallurgical & Chemical Engineering" has been published as a semi-monthly. Thus it was left to Mr. McGraw, already the leading technical publisher in the electrical, electric railway, and civil engineering fields, to give to the new professions of the chemical and metallurgical engineers their technical newspaper. The growth of this journal during the past few years has been phenomenal.

The latest additions to the list of McGraw papers were "Electrical Merchandising" and "The Contractor." Since 1906 the McGraw papers have had their own home at 239 West Thirty-ninth Street, New York.

* * *

The history of the development of the Hill Publishing Company, like that of the McGraw Publishing Company, Inc., with which it has become consolidated, is built largely around the efforts of one man. The late John Alexander Hill, founder of the house which bore his name, began his publishing career by the acquisition of "Locomotive Engineering," a paper on whose editorial staff, a few years before, he had been given a position as editor. With Mr. Hill at its head, the journal soon became successful. Hardly had it become firmly established when Mr. Hill sold it and purchased the "American Machinist."

Since its formation in 1902, the Hill Publishing Company has reached a position in the front rank of technical journalism. It had its beginning in the consolidation of the American Machinist Press, publisher of the weekly "American Machinist," and the Power Publishing Company, publisher of the monthly "Power." In 1905, the weekly "Engineering and Mining Journal" was purchased. In 1908 the semi-monthly paper, "The Engineer," of Chicago, was consolidated with "Power" and the latter paper was made a weekly. In 1911 "Engineering News" was purchased. A new weekly paper, "Coal Age," was started in October, 1911, its field being coal mining and coke manufacture. Four years later the "Colliery Engineer," published in Scranton, was bought and consolidated with "Coal Age." The "Mining and Engineering World," published in Chicago, was acquired in December, 1916, and consolidated with the "Engineering and Mining Journal." A home for the Hill papers was provided in 1914 in the beautiful Hill Building at Tenth Avenue and Thirty-sixth Street.

After Mr. Hill's death in 1916, Arthur J. Baldwin was appointed to the presidency of the Hill Publishing Company. Mr. Baldwin, the new vice-president and treasurer of the McGraw-Hill Publishing Company, Inc., is a lawyer by profession and for many years was closely associated with Mr. Hill.

In 1909 the respective book departments of the McGraw Publishing Company and of the Hill Publishing Company were consolidated into the McGraw-Hill Book Company, which has been eminently successful and is the largest technical book publisher in the world.

This merger has now been followed by the much bigger consolidation of the two publishing companies themselves. Mr. McGraw has realized the dream of a life time.

The New York Section of the American Chemical Society Celebrates Its Twenty-fifth Anniversary

On Friday evening, March 9, at a joint meeting of the New York Sections of the three chemical societies, the New York Section of the American Chemical Society celebrated its twenty-fifth birthday. The Chemists' Club Hall was prettily decorated with flags and greens and nearly 300 chemists and engineers attended. An elaborate supper introduced the festivities. After that the members were invited to the main hall where sumptuous plans had been made for a smoker and entertainment.

After a brief business session at which officers for the next session were elected (chairman, Dr. Herty; secretary-treasurer, Mr. Roth), Dr. Matthews introduced the first speaker of the evening, Provost Professor EDGAR F. SMITH of the University of Pennsylvania. Professor Smith congratulated the section upon its twenty-five years of existence and thought this to be a very appropriate occasion to look back on the past and see what some of our fellow chemists had accomplished. Our tendency to-day is to rush along with hardly a thought as to what others before us have achieved. Professor Smith then gave a brief outline of the eventful life and remarkable career of Robert Hare, the pioneer electrochemist of America and in many respects of the world. It was Hare who invented the oxy-hydrogen flame torch which gave rise to the founding of the great Bishop Platinum Works, and the Drummond light, at one time the standard for all lighthouses. These researches were carried out in a very primitive laboratory in the brewery of Hare's father and most of his time Hare had to devote to details of brewing. It was Hare also who first applied a mercury cathode in aqueous bath electrolysis and produced in this way sodium, calcium, barium, etc. Hare had built a large copper-zinc battery and the current obtained from it he utilized in a hundred different ways. He heated amorphous carbon and produced the first specimen of artificial graphite. He heated lime and carbon and produced calcium carbide. It was Hare, too, who devised the first gas analytical apparatus and Professor Smith had but recently succeeded in acquiring one of Hare's original gas apparatus. Professor Smith spoke in his usual fascinating style and his talk was very much appreciated.

Upon the conclusion, Dr. Baekeland moved that this 25th anniversary be commemorated by the gift of a bronze bust of Hare to the Chemists' Club. The suggestion was enthusiastically received.

The second speaker of the evening was Dr. WM. H. NICHOLS, who in a very elaborate paper outlined the early history of the American Chemical society. Dr. Nichols showed the audience copies of the first announcements, program of the first meeting (1876), constitution and by-laws, membership lists, etc. Of the 140 members who filled the first year's register but five are living to-day. "Like many of the best things of the world the American Chemical Society was founded by a woman" (who suggested the idea to Dr. Chandler).

The third speaker was Dr. E. G. LOVE, who chose for his topic "The First Years of the New York Section." As treasurer of the Society he was particularly interested in the rapid financial growth of the Society.

The first chairman of the section was Dr. A. H. Sabin (National Lead Co.). Dr. Sabin, who was one of the honored guests, received a great ovation and the first "Salamander" of the evening was "rubbed" in his honor. Dr. C. F. Chandler, the dean of American Chemistry, who was also expected to attend, was unfortunately unable to be present.

During the course of the evening Dr. Chas. A. Doremus presented to the section, in commemoration of its twenty-fifth birthday, a large steel-engraving of the first president of the American Chemical Society, Prof. J. W. Draper, who was a graduate of the University of Pennsylvania and from 1837 till his death in 1882 was professor of chemistry at New York University. He had gained a world-wide reputation through his researches on spectrum analysis and photography.

At the conclusion of the formal addresses refreshments were served and entertainment of the true smoker style was provided for. Dr. E. C. LOVE made a splendid stage manager. It was long after midnight when the celebration came to a close.

Opportunities for Investment of American Capital in Foreign Fields

Discussion Before Mining Engineers

The March meeting of the New York Section of the American Institute of Mining Engineers was held at Whyte's restaurant on Friday evening, March 9. Percy E. Barbour, who presided in the absence of David H. Browne, introduced WILLIAM S. KIES, vice-president of the American International Corporation. Mr. Kies gave an interesting talk on the international financial situation and the possibilities for the investment of American capital in foreign fields, now and after the war.

He explained the great difference which exists in our financial situation now, as compared with that before the war. Up until that time we had always been a borrowing nation, owing on an average 5 billion dollars. In the short space of two and a half years we have paid off all our foreign obligations and at the end of last year had a favorable balance of trade of 2½ billions. Outside of Mexico and the sugar investments in Cuba, we have not had any foreign investments. On account of the change in the financial situation, however, there is and will be considerable American capital available for investment.

In discussing the fields for this capital Mr. Kies first took up the domestic situation. He said America will need capital to keep on building up her own industries, cities, etc. The greatest users of capital here are the railroads, but Mr. Kies said that under their present mongrel rule they will be unable to go into the market and bid for capital, and are not to be considered as good investments. The same is true of public utilities.

In the foreign field China presents the greatest possibilities, excluding the belligerent countries. Money will be needed there for new railroads, public utilities, improvements, etc. The South American situation needs careful study and does not present such glowing possibilities as some people think. Several of the South American countries have bad credit records, and the governments exercise careful control over the building of railroads.

Mr. Kies said that the United States will have a great obligation in being the custodian of capital which the foreign countries will need, and he thinks the gospel of saving and of elimination of waste ought to be spread in every direction in order that we may hold the ground thus far attained and be able to compete favorably with foreign countries after the war.

He outlined the reason for the formation of the American International Corporation, which was to investigate propositions in foreign fields. The company has gathered a vast amount of information especially from Central and South America, and while as yet but

few propositions have been financed owing to their not measuring up to the standard set by the company, several are expected to develop when more capital becomes available. The company may issue bonds in its own name for the financing of foreign propositions.

Mr. J. Morgan Clement was the second speaker, and told of the intention of the U. S. Government to make an investigation of the Mineral Resources of the Far East, at present, especially in China, Manchuria, and the Orient.

The Thiogen Process for Removing Sulphur Fumes

The thiogen process for eliminating the deleterious sulphur dioxide from smelter fumes and converting it into free elemental sulphur as a useful product, has been noticed many times in journal notes and articles. But the only full description of it we know of, has been given in a paper by the inventor, Prof. **S. W. Young**, of Leland Stanford University, at the San Francisco meeting of the American Institute of Chemical Engineers. From the *Transactions* of the Institute we reproduce Professor Young's paper practically in full in all essentials.

The fundamental chemistry of the proposed process lies in the simple reduction of the sulphur dioxide to sulphur by means of carbonaceous or hydrocarbonaceous materials. In localities where natural petroleum is readily available, it, in some form or other, would be the most desirable material for the purpose. It may be assumed that petroleums are to be used for the purpose, and that their composition is sufficiently closely represented by the formula CH_2. The theoretical equation representing the reduction of sulphur dioxide by such hydrocarbon material is as follows:

$$3SO_2 + 2CH_2 = 3S + 2CO_2 + 2H_2O \qquad (1)$$

This equation represents the theoretical maximum chemical efficiency which the process could attain under any condition. It will be seen that, working at this maximum efficiency, 28 tons of hydrocarbon would produce 96 tons of sulphur. This is, of course, taking no account of hydrocarbon used as fuel or for any other purpose.

The patents owned by the Thiogen Company cover two general methods of carrying out the above mentioned reduction of sulphur dioxide, one known as the "dry process," and the other as the "wet process." The experimental developments of the two processes have been of wholly different character, and the experiments have been carried out independently.

THE "DRY PROCESS"

If one attempts to carry out the reduction of sulphur dioxide by means of hydrocarbon vapors in combustion tubes, very complex and incomplete reactions occur, which result in considerable evil-smelling vapors and much unattacked sulphur dioxide. Even at temperatures too high to be available for practical operations, the reaction is too slow to be of any use. In the investigations leading to the Thiogen patents, a number of satisfactory catalysers were found. These are all compounds of such metallic elements as yield sulphides readily by reduction of sulphates or sulphites, and whose sulphides are infusible and readily converted back to sulphites or sulphates by the action of sulphur dioxide. Such sulphides as those of calcium, barium and magnesium seem to give the best products for this purpose. A little thought will make clear the probable catalytic action of the compounds of these metals.

If we start with say calcium sulphate and treat it at elevated temperatures with hydrocarbon vapors, it becomes reduced to calcium sulphide. If, still at elevated temperature, the sulphide be treated with sulphur dioxide, the following equation represents the reaction which occurs:

$$CaS + 2SO_2 = CaSO_4 + 2S \qquad (2)$$

A few experiments in the laboratory very soon demonstrated the fact that the reduction of calcium or other sulphate to sulphide and its reconversion to sulphate and free sulphur by means of sulphur dioxide could go on readily side by side. That is, if sulphur dioxide mixed with hydrocarbon vapors in the proper proportions is passed through a heated combustion tube containing fragments of calcium sulphate, the reduction of the sulphur dioxide takes place with great ease and rapidity, and the products are mainly sulphur, carbon dioxide, and water vapor. Little or no carbon monoxide is found unless excess of hydrocarbon is used. This is the fundamental principle of the Thiogen "dry process."

The Penn Mining Company, with a smelter located at Camp Seco, California, placed at the disposal of the Thiogen Company ground space, gases, materials, and money for a very considerable series of experiments on a commercial scale. After one or two series of experiments with various forms of apparatus, experience seemed to point to a vertical reaction chamber as best for the purpose. This was constructed of large iron pipe 5 feet in diameter and 20 ft. high. It was lined with fire brick, and four stationary hearths were built in. On these hearths was placed the contact material. This was made up of plaster of paris, which was slopped and allowed to set, after which it was thoroughly dried and broken into lumps about as large as the hand, so that when installed on the hearths it made loosely porous masses, affording good mixing and contact for the reacting gases. Each hearth was provided with manholes for cleanout and replacement, as well as with tubulations for gas sampling throughout the period of operation. A system of pyrometers was also installed whereby records of temperatures on all the hearths could be obtained.

Below the fourth hearth were the intake for the roaster gases to be treated, and two crudeoil burners. Two burners were used instead of one, to increase the range and accuracy of regulation. The roaster from which the gases were taken was an ordinary McDougal. It was provided with a by-pass system and fan blower, whereby a part of the gases could be continuously returned through the roaster. It was thus possible to get gases of fairly constant compositions for sufficient periods of experiment, and under favorable conditions it was possible to maintain a fairly steady flow of gas as high as 11 per cent sulphur dioxide, for sufficiently long periods to be useful for experiments.

In beginning a run, the procedure was to first start the oil burners, with air draughts, and to keep up the firing until the contact material on all hearths was a good bright red. The air draught was then cut down and the roaster gases admitted. Analyses were continuously taken from all the hearths. These showed at first complete reduction on the first hearth. After a time this hearth began to cool down and reduction was imperfect. The second hearth, however, showed perfect reduction for a time, when this also began to cool off, and so on until the whole apparatus went out of action. This cooling action could be ascribed to two causes: First, absorption of heat by vaporization of the oil; second, the oncoming roaster gases were too cold (they had been cooled to about atmospheric temperature by a scrubber in order to remove dust).

An outside vaporizing chamber for oil was built, and while this assisted somewhat, the same cooling as before occurred. A rather elaborate pre-heating apparatus for

the gases was then designed, but unfortunately at about this time the company encountered difficulties with their mining operations which made it seem doubtful wisdom for them to continue financing the experiments. So the experiments were terminated. In the meantime considerable valuable information had been obtained which is summarized as follows:

(1) Under favorable conditions the reaction between sulphur dioxide and hydrocarbon vapors in contact with the calcareous material is extremely rapid. It was never possible to force the apparatus beyond capacity.

(2) The process does not offer any hope of working well with gases under 7 per cent in sulphur dioxide. At lower percentages than this considerable sooting occurs, which puts the contact mass out of commission.

(3) In order to operate successfully, the process will demand preheating of the gases. To just what temperature this preheating must go it is impossible to say in absence of experimental evidence. The calculated values do not indicate that it is likely to be an especially difficult matter.

(4) The dry process undoubtedly contains the elements of a successful commercial process for producing sulphur, under the condition that the plant producing the gases will operate for high concentration gases. Seven per cent sulphur dioxide is necessary, and the higher the percentage goes the better, as every drop in sulphur dioxide content means additional oxygen to burn out, and additional oil costs per ton of sulphur.

THE WET PROCESS

The Thiogen wet process proposed to accomplish the same end as the dry process, namely the reduction of sulphur dioxide to sulphur by hydrocarbon vapors or carbonaceous material, but it accomplishes this result in a far different way. It was the first of the two processes to be devised. The general procedure in the wet process is as follows:

(1) The sulphur dioxide is first absorbed in water in appropriate absorption towers. This operation takes place in accordance with well-known laws and needs no further discussion.

(2) This solution of sulphur dioxide in water is mixed and allowed to react with a paste or solution of a suitable sulphide. The most suitable sulphide for this purpose that was found thus far is barium sulphide. When sulphur dioxide reacts with basic sulphides in the wet state, the processes which occur are rather complex. Considerable free sulphur is formed, and in addition, sulphides, thiosulphites and thionates of the metal used. The formation of some complex sulphur salts is a matter of little moment, since in the further operations they break down, and furnish their equivalent of free sulphur.

(3) As a result of the treatment described under (2) there is formed a sludge whose solid components are free sulphur and the sulphur salts of the metal used. If the treatment is properly carried out, these solids settle and filter with greatest ease, and the supernatant liquid is practically pure water, which may again be returned to the absorption towers.

(4) The solids of the sludge, after settlement and filtration are dried, and then raised to a temperature of from 450 deg. to 500 deg. C. In this way the complex sulphur salts are broken down and the total sulphur available as free sulphur is distilled off and condensed. The still residue consists of a mixture of sulphite and sulphate together with some sulphide under certain conditions. The sulphide is formed as a result of the well-known breakdown of sulphites into sulphides and sulphates at higher temperatures.

(5) The residual sulphites and sulphides are next passed through an appropriate furnace where they are reduced back to sulphide, and are then again ready to be brought into reaction with further quantities of sulphur dioxide solutions. There is thus accomplished a cycle of operations whereby nothing is used up but sulphur dioxide and reducing materials, for which there is produced an output of free marketable sulphur.

The reason for choosing barium sulphide instead of the cheaper calcium sulphides are chiefly as follows:

(1) Barium sulphide is readily and rapidly soluble in water, while calcium sulphide is not. Thus ease of intimate mixing and rapid reaction with the sulphur dioxide liquor is greatly favored by the use of the barium compounds.

(2) The sulphite, sulphate and the complete sulphur salts of barium are much more insoluble than the corresponding salts of calcium. This prevents the building up of any disadvantageous concentrations of these salts in the water used in the operation.

(3) The barium salts all crystallize anhydrous while the calcium salts all carry water of crystallization in considerable amounts. This means a great saving in the heat demanded in process (4) of the cycle, namely the drying of the filtered sludge. If calcium salts are used, the preparation of the solids for distillation would demand not merely the drying away of adherent water, but also the driving off of large quantities of water of crystallization.

(4) The settling and filtering properties of the barium sludges are vastly superior to those of the calcium ones.

All phases of operation of the wet process have been worked out quite thoroughly by Professor Young and his co-workers in the laboratory, and all members of the cycle have been realized practically. The element which offers the greatest difficulty is the reduction of the still residues to sulphide.

As to the relative merits of the two processes, the wet process has the great advantage of operating under present conditions of roaster and blast furnace operations, namely low concentration of sulphur dioxide. On the other hand, Professor Young still firmly believes that wherever roasting for high concentration could be introduced, the dry process would prove the more economical for the production of sulphur.

Actual Work Begun in Course of Chemical Engineering Practice

In his report recently made to the Massachusetts Institute of Technology Alumni Council with reference to the opening of the new course in chemical engineering practice (see this journal, Aug. 1, 1916, Vol. 15, p. 138), Dr. W. H. Walker, director of the course, noted particularly the conditions at Bangor and Stamford, places which he had just visited. Both students and manufacturers are very enthusiastic about the work.

"At Bangor the students are engaged this week in a survey of the processes of the Penobscot Fiber Company, at Great Works, Me., where their study will be losses of soda in various processes, data which the manufacturers much desire but which it has not heretofore been convenient to secure. The presence in any plant of a group of young men who can devote their time and efforts to definite research work in the minutiæ of the processes is likely to afford information of value in the refinement of the technique. At Bangor this group has already made an elaborate test of the electrolytic plant of the Eastern Manufacturing Comapny, the products of whose processes are chlorine and caustic soda.

"At Stamford the students have had considerable experience in the handling of machinery and outfit in addition to chemical work."

Current Density in Copper Refining

By Lawrence Addicks

The current density, or amperes per square foot of active cathode surface, is the factor in an electrolytic process, such as copper refining, upon which above all others the design and operation of the plant depend, as upon it hangs a string of minor factors which must be properly correlated in order to obtain the best return upon the investment. These factors may be classified under cost per pound of cathodes recovered, first cost of plant, and metallurgical purity of product.

Aside from commercial considerations there is a limit to the density which can be employed imposed by the temperature of the electrolyte. By far the larger part of the electrical energy called for is converted into heat in overcoming the ohmic resistance of the cells and the temperature of the electrolyte rises until the heat losses offset the C^2R gain.

The electrodes are spaced so closely in the tanks that the equivalent energy to be dissipated is quite large and further at about 150° F. a liquid will begin to steam sufficiently to make a tank room too foggy for comfort or for efficient inspection. As a starting point we may first examine this question of temperature of electrolyte.

Temperature of Electrolyte

In ordinary practice with moderate densities the electrical energy is supplemented by a certain amount of either live or exhaust steam to obtain the desired temperature of operation generally in the neighborhood of 130 deg. Fahr. This requires a balancing of the cost of heating against the gains resulting. In a previous article (Analysis of Tank Resistance in Electrolytic Refining, Nov. 15, 1916) we have considered in detail the question of tank resistance and took as an example a certain case which showed the distribution of resistance shown in Table I.

TABLE I—TANK RESISTANCE

	Ohms per Tank	Per Cent of Total	Class
A. Electrolyte	0.0000444	55.1	Ohmic
B. a. Leads	0.0000024	3.0	Ohmic
b. Conductor bars	0.0000085	10.5	Ohmic
c. Anodes	0.0000002	0.25	Ohmic
d. Cathode rods	0.0000010	1.2	Ohmic
e. Cathodes	0.0000008	1.0	Ohmic
f. Connection strips	0.0000002	0.25	Ohmic
C. a. Anode contact	0.0000026	3.2	Ohmic
b. Cathode loop contact	0.0000043	5.3	Ohmic
c. Cathode rod contact	0.0000044	5.5	Ohmic
D. Counter electro-motive force	0.0000040	5.0	E.M.F.
E. Slimes, etc., by difference	0.0000078	9.7	Ohmic
Total	0.0000806	100.0	.....

Increasing the temperature of the electrolyte will lower its resistance by an amount proportionate to the increase and to its temperature coefficient of about 0.5 per cent per degree Fahr. It will increase the resistance of the various metallic resistances and contacts which it can affect.

As the anodes and cathodes are the only submerged metallic resistances and as they are of negligible resistance, we may turn to the exposed resistances and contacts. The leads and conductor bars along the sides of the tanks are too far removed from the source of heat to be much affected. The contacts are kept well above room temperature by their own C^2R loss.

The temperature coefficient of copper is plus 0.24 per cent per degree Fahrenheit.

I think we may safely assume that the total change in these minor resistances with change in temperature of the electrolyte is very small. The "transfer" resistance at the surfaces of the electrodes is markedly lowered by increase of temperature, but this gain is large only in the lower part of the temperature range.

We may therefore consider the temperature coefficient as approximately minus 0.5 per cent. per degree Fahrenheit at high temperatures and a larger figure at low temperatures due to the added change in "transfer" resistance.

When running at about sixteen amperes per square foot of cathode surface without the use of any steam for heating, the electrolyte in an average system will run about 25 deg. Fahr. above the temperature of the atmosphere in the tank room, which latter is generally around 70 deg. Fahr. and very humid unless an adequate system of forced ventilation is employed.

Some simple tests where a circuit was allowed to run without any heating steam until at temperature equilibrium and then heating as rapidly as possible in the solution wells showed the results given in Table II.

TABLE II—EFFECT OF TEMPERATURE OF ELECTROLYTE ON TANK RESISTANCE

Test No.	Ohms per Tank			Deg. Fahr.			Ohms per Degree	Temp. Coeff. per Cent
	Initial	Final	Diff.	Initial	Final	Diff.		
1	0.000094	0.000089	0.000005	102	121	19	0.00000026	0.29
2	0.000097	0.000087	0.000010	103	122	19	0.00000053	0.61
3	0.000091	0.000082	0.000009	108	128	20	0.00000045	0.55
4	0.000096	0.000088	0.000008	105	118	13	0.00000061	0.69
Av.	0.000095	0.000087	0.000008	105	122	17	0.00000047	0.54

Current = 4400 amperes — Watts per tank without steam = 1840

This temperature coefficient of 0.54 per cent per degree Fahrenheit is so large that it at once becomes apparent that the application of direct heat to the electrolyte should be considered. Some interesting tests were carried out at another plant by measuring the temperature of the electrolyte, amperes and voltage

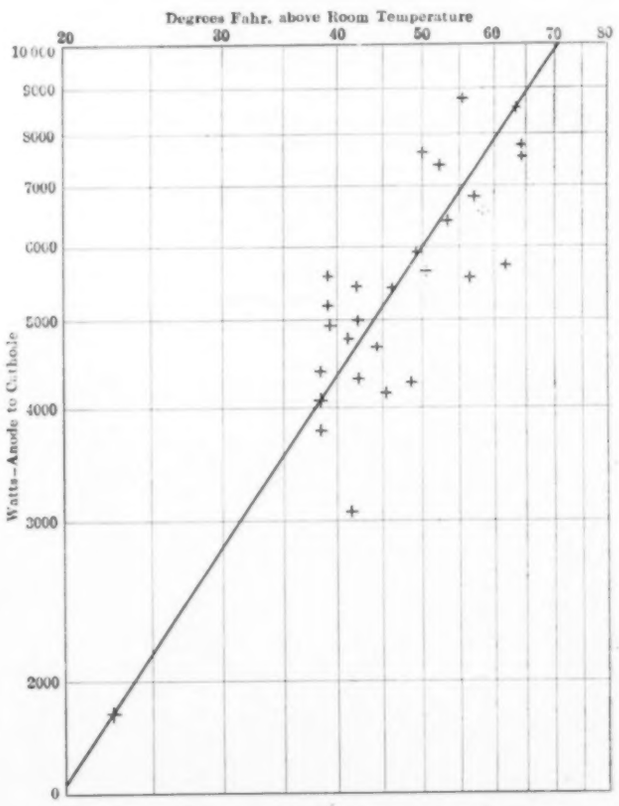


FIG. 1—WATTS TO MAINTAIN TEMPERATURE OF ELECTROLYTE

from anode ear to cathode loop, for different current densities without direct heat.

Some of the results obtained are shown in Fig. 1. The watts per tank required to maintain a certain temperature is a measure of the rate of cooling at that temperature and the curve is therefore exponential. Plotting the data on logarithmic section paper indicates a law of

$$\text{Watts per tank} = 20.8 \times (^\circ \text{Fahrenheit liquor} - ^\circ \text{Fahrenheit atmosphere})^{1.45}.$$

This formula is, of course, only good for the conditions at the particular tank house where the tests were conducted. At a room temperature of 70 deg. Fahr. this formula would give our practical limit temperature of 150 deg. Fahrenheit in the electrolyte with 12,000 watts per tank.

Under the conditions of this set of tests the internal tank resistance would be about 0.00003 ohm and 12,000 watts would correspond to a current of 20,000 amperes and a current density of 64 amperes per square foot. This is far above any density ever likely to be applied in practice unless marked changes in the general arrangement of the process develop.

With a density of 45 amperes per square foot the electrolyte would probably run about 120 deg. Fahr. and the use of steam for heating would hardly be justified. At lower densities we have the usual case of heating in the solution wells by steam.

If we figure out a heat balance between live steam for heating and the saving at the boilers for decreased electrical power for electrolysis we shall find that the total cost increases as the electrolyte is heated.

The earlier plants did use live steam for heating but the more recent installations have used exhaust steam, in some cases obtained by operating some of the main generating units under partial vacuum, and this changes the entire situation.

Another result of heating the electrolyte is to increase the growth of copper in solution due to the oxidizing effect of the liquor. Copper is not ordinarily considered soluble in dilute sulphuric acid but when the solution is aerated by passing from tank to tank the oxygen dissolved brings about slow solution.

Fig. 2 shows the rate of action of a solution carrying 3 per cent. copper and varying percentages of free acid upon a piece of cathode copper about 3 x 3 inches, as the temperature is raised in a beaker. This shows that the degree of attack rapidly increases with rising temperature, and is practically independent of the degree of acidity. This action may or may not be desirable according to circumstances.

Where quite pure anodes are being refined the excess copper builds up in the electrolyte and is usually removed by means of insoluble anode or "liberating" tanks. As these operate at from 2.0 to 2.3 volts or some seven times as much as ordinary depositing tanks require, this power tends to offset the resistance saving due to hot electrolyte.

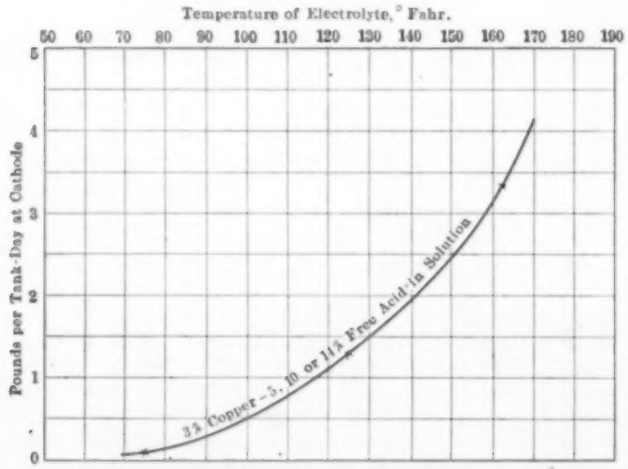

Temperature of Electrolyte, ° Fahr.
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Pounds per Tank-Day at Cathode
0 1 2 3 4 5
3% Copper—3, 10 or 14% Free Acid in Solution

FIG. 2—CHEMICAL CORROSION OF COPPER BY ELECTROLYTE

When, on the other hand, the anodes carry considerable percentages of nickel, cobalt, etc., a proportion of the current is employed dissolving these substances electrochemically at the anode while depositing an equivalent quantity of copper at the cathode, so that the nickel, etc., will grow in the electrolyte which is at the same time depleted in copper. Then the addition of copper by chemical corrosion is very welcome; in fact in extreme cases this effect has to be artificially increased by the use of towers of shot copper or similar means.

In general it is found necessary to use from 2 per cent of liberating tanks at one extreme to no liberating tanks and shot towers at the other.

The temperature of the electrolyte also has a bearing upon the shrinkage in volume in the electrolyte due to evaporation. Now that it is customary to use a purifying process on a closed cycle evaporation gives almost the only means of making room for water used in rinsing the anodes and cathodes.

The final and really controlling reason for the use of warm electrolyte is the greatly improved metallurgical conditions resulting therefrom. Not only is the cathode smoother and denser, but the conditions at the dissolving surface of the anode are greatly benefited.

The increased temperature brings about a local circulation which assists in removing the dense solution of copper sulphate from the face of the anode and in preventing stratification in the tank.

When current is passed through a cold cell without any circulation of the electrolyte conditions soon become so unbalanced that the electrodes will gas, the voltage show violent fluctuations and the anode slimes be stirred up and carried in suspension, thereby fouling the cathode.

When the electrolyte is systematically circulated these bad effects are counteracted, but the rate of circulation which can be employed is limited by the eventual stirring up of the slimes mechanically.

There is in turn a current density for this limiting circulation which begins to bring about a return of the undesirable gassing and for a cold liquor and an impure anode this density is so low as to require an abnormally large plant investment.

When the electrolyte is heated this density limit is greatly raised and it was practice even in the very early days to heat the electrolyte somewhat—perhaps to 110 deg. Fahr.—and later this temperature has been graduall increased until 135 deg. Fahr. entering the tanks is not uncommon.

In series system plants the tanks have commonly been lined with some asphalt composition which softens with heat and this has made it impracticable to use temperatures as high as would be otherwise desirable, and is one of the reasons that series processes require relatively pure anodes.

In general, therefore, (1) the temperature of the electrolyte should be carried well up toward the practical limit of 150 deg. Fahr. in order to be able to employ as high a current density as may be desirable from the point of view of cost of operation; (2) unless a very high density permitted by very unusual conditions is employed, heating in the solution well will be required to maintain this temperature; (3) with proper exhaust steam design this heating will be practically free of direct expense.

Power

Assume a tank resistance of 0.0000766 ohm, a counter e.m.f. of 0.010 volt per tank, 24 pairs of 2 ft. x 3 ft. anodes and cathodes, making 288 sq. ft. of surface and 90 per cent current efficiency. As we increase the current density we shall have the conditions shown in Table III.

TABLE III—RELATION BETWEEN CURRENT DENSITY AND POWER COST

Amperes per Sq. Ft.	Amperes	Volts	Watts	Lbs. Copper per 24 Hours	Watt-Hours per 24 Hours	Watt-Hours per Lb. Copper
5	1,440	0.120	173	81	4,200	52
10	2,880	0.231	665	162	16,000	99
15	4,320	0.341	1,470	243	35,300	145
20	5,760	0.451	2,600	324	62,400	193
25	7,200	0.562	4,050	405	97,200	240
30	8,640	0.672	5,810	486	139,400	287
35	10,080	0.782	7,900	567	189,600	335
40	11,520	0.892	10,260	648	246,200	381

This table shows that the power cost per pound of copper rises nearly in proportion to the current density employed.

It is true that we have assumed a constant tank resistance due to maintaining the electrolye at a constant temperature by means of steam.

As the current density is raised the electrical heat dissipated in the tanks will increase, as previously discussed and this will mean that less heating steam will be required and this saving will give some credit to be applied against the power cost.

It is evident that the cost of producing a kilowatt-hour will have a great deal to do with the question; in fact it is possible to plot the power cost at various plants against the current density used and obtain quite a smooth curve. Fig. 3 shows this general relation, but individual cases may show exceptions for special reasons.

First Cost of Plant

Assume that the tank house equipment in the example taken amounts to an investment of $300 a tank and that the power plant costs $80 a kilowatt. As the former will vary with the output of cathodes per tank day and the latter with the kilowatt demand, both of which depend upon the current density, we can take the relations determined in Table III and ascertain the joint influence of these two factors, which has been done in Table IV.

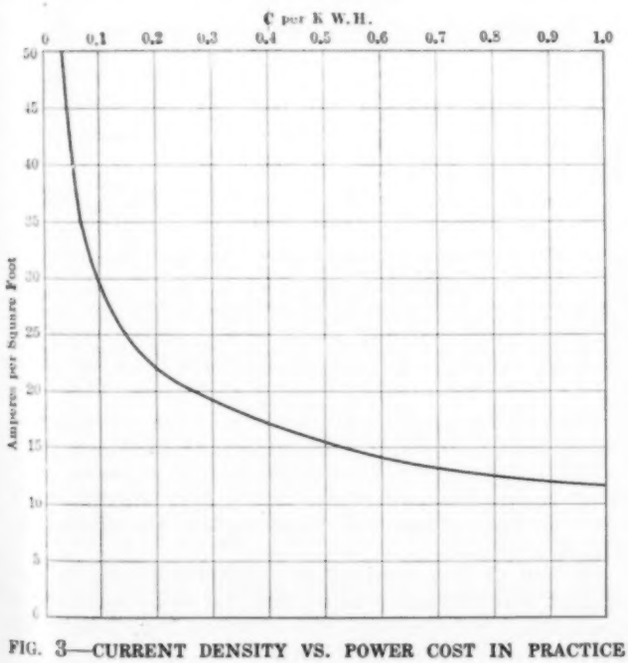


FIG. 3—CURRENT DENSITY VS. POWER COST IN PRACTICE

TABLE IV—RELATION BETWEEN CURRENT DENSITY AND COST OF PLANT

Current Density	Lbs. Copper per Tank-Day	Tank Investment per Lb. Copper per Day	Watt-Hours per Lb. Copper	Watts per Lb. Copper per Day	Power Plant Investment	Total Investment per Lb. Copper per Day
5	81	$3.60	52	2.16	0.17	$3.77
10	162	1.85	99	4.12	0.33	2.18
15	243	1.23	145	6.04	0.48	1.71
20	324	0.92	193	8.06	0.65	1.57
25	405	0.74	240	10.00	0.80	1.54
30	486	0.62	287	11.90	0.95	1.57
35	567	0.53	335	13.90	1.11	1.64
40	648	0.46	381	15.80	1.26	1.72

Labor Cost

The main labor items in operating a tank house are for inspection work to maintain current efficiency and for inserting and drawing the electrodes as the copper moves through the process.

The higher the current density the more difficult is it to maintain the efficiency on account of the increased number of short circuits caused by rough deposits on the cathodes.

After the circulation of the electrolyte has been raised to the highest rate which will not stir up slimes and addition agents have been added to control the character of the deposit as much as possible, the only ways to maintain efficiency are either to steadily increase the inspection labor or to decrease the life of the cathodes.

Actually as the density rises the efficiency in practice is sacrificed a little, the labor is increased and the age of the cathodes decreased until a balance is struck.

The cost of making starting sheets in the multiple process also enters if the weight of the individual cathodes is changed. We shall confine ourselves to an inquiry into the effect of age of electrodes upon the labor cost.

Age of Electrodes

The age of the anodes and the proportion of anode scrap made have but little connection with the current density, except that four anodes which give heavy scrap

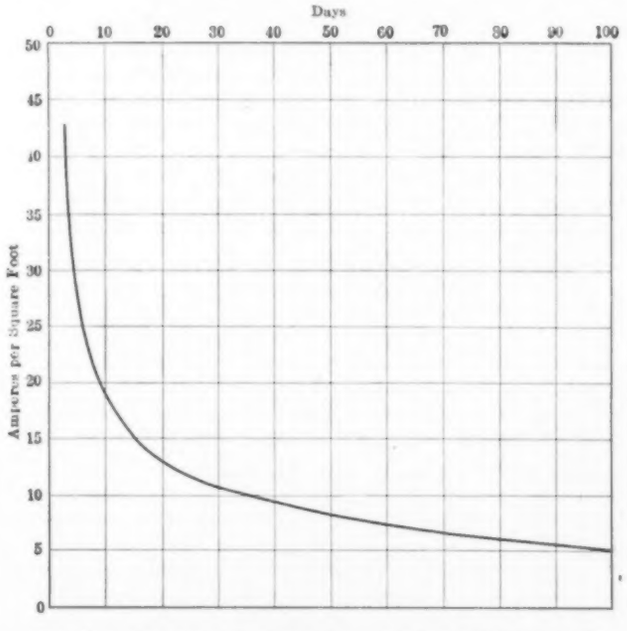


FIG. 4—CURRENT DENSITY VS. AGE OF CATHODES IN PRACTICE

will work at increasing disadvantage as the density is increased.

In the case of cathodes we may observe a general relation between age and density as shown by the practice at different plants and given in Fig. 4. The increasing knowledge of the value of addition agents in recent years has tended to lessen the slope of this curve, however, and the day of the very low density plant has apparently passed.

Taking this curve as a basis and assuming that a starting sheet costs one cent to make and that it costs two cents a cathode to handle sheets in and cathodes out of the tanks, making a total of three cents, we can figure as in Table IV the cost of changing age with density.

TABLE V—RELATION BETWEEN CURRENT DENSITY AND AGE OF CATHODES

Current Density	Lbs. per Tank Day	Lbs. per Cathode Day	Cathode Age in Days	Lbs. per Cathode	Cathodes per Ton	Total per Ton
5	81	3.4	100.0	340	5.9	0.18
10	162	6.7	37.0	247	8.1	0.24
15	243	10.1	15.2	154	13.0	0.39
20	324	13.5	9.6	130	15.3	0.46
25	405	16.9	6.8	115	17.4	0.52
30	486	20.2	5.2	105	19.0	0.57
35	567	23.7	4.0	95	21.1	0.63
40	648	27.0	3.2	86	23.3	0.70

Metallurgical Effects of Current Density

A high current density will always give trouble at the anode when treating foul material and usually bring about abnormally high voltage conditions. But even where normally pure anodes are refined the disturbance of the slimes is greater as the density is raised, due partly to the necessarily somewhat increased mechanical circulation and partly to local gassing or heat disturbances at the face of the anode.

This relation can be clearly traced in the purity of the cathode and while it is ordinarily not sufficient in magnitude to affect the commercial purity of the copper as such, it can be clearly felt in the silver and gold losses carried away in the cathodes.

The percentage of the silver and gold in the anodes which is found in the cathodes at various plants is plotted against the current density in use in Fig. 5. Where the anodes are rich in values this factor may be of some importance.

Financing Metals in Process

In a previous article (The Metal Tie-Up in Electrolytic Refining, Sept. 15, 1916) it was shown that the copper, silver and gold are tied up in the tank house an equivalent of 25 days in ordinary eastern practice, which means a current density of about 20 amperes per square foot. It is evident that this time will vary with any change in the density, and for simplicity's sake we shall assume that this variation will be in

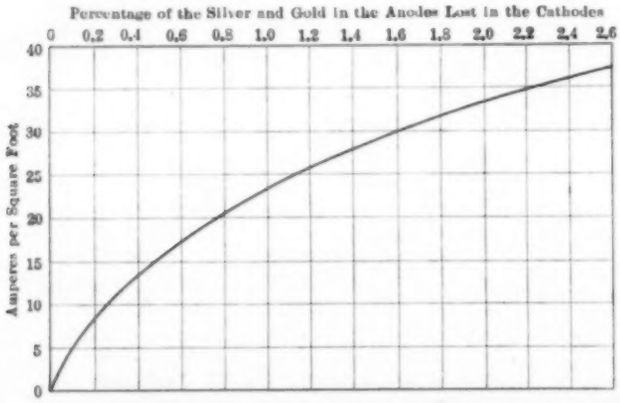


FIG. 5—CURRENT DENSITY VS. METAL LOSSES IN PRACTICE

straight inverse proportion, although it is quite possible to change the weight of the anode or percentage of scrap at the same time.

Taking copper at an ante-bellum price of fifteen cents a pound and silver and gold values of varying amounts and interest at six per cent per annum (see the article referred to), we have the situation shown in Table VI.

TABLE VI—RELATION BETWEEN CURRENT DENSITY AND METALS TIED-UP

Current Density	Days in Tank House	Interest Charges per Ton at 6 per Cent with Silver and Gold per Ton at $25	$50	$75	$100	$200	$300
5	100	$5.42	$5.83	$6.25	$6.67	$8.33	$10.00
10	50	2.71	2.92	3.13	3.34	4.17	5.00
15	33.3	1.81	1.94	2.08	2.22	2.78	3.33
20	25	1.36	1.46	1.56	1.67	2.08	2.50
25	20	1.08	1.17	1.25	1.33	1.67	2.00
30	16.7	0.90	0.97	1.04	1.11	1.39	1.67
35	14.3	0.78	0.83	0.89	0.95	1.19	1.43
40	12.5	0.68	0.73	0.78	0.83	1.04	1.25

Summary

The data in the previous paragraphs are general in character and do not strictly represent any particular plant, but they serve to illustrate the general relations between current density and cost of operation which have to be considered in designing an electrolytic plant.

The first step in such a design after determining the desired capacity of the proposed plant and the probable cost of power per kilowatt hour is to combine the data given under the various preceding headings and determine the approximate current density, thereby settling the size of the tank house and power plant.

As an illustration and without carrying such an analysis into the details necessary in actual work we will assume that the gain from released heat just offsets the loss from decreased current efficiency as the density is raised; that interest and depreciation on the tank house and power plant shall be 20 per cent per annum; that the silver and gold values in the anodes amount to $100 a ton; and that we are interested in five locations where the probable power cost is estimated at 1/10c., ¼c., ½c., ¾c. and 1c. per kilowatt-hour respectively, and other conditions are equal.

These assumptions are combined with the data from the several tables and diagrams in Table VII.

TABLE VII—GENERAL RELATION BETWEEN CURRENT DENSITY AND COST

Current Density	Kw.-H. per Ton	$ Investment per Ton-Day	Cost in Dollars per Ton: Interest and Depreciation	Metal Interest	Metal Loss	Labor	Power 1-10c	Power ¼c	Power ½c	Power ¾c	Power 1c	Dollars per Ton: Total Operating Cost 1-10c	¼c	½c	¾c	1c
5	1.04	7540	4.19	6.67	0.09	0.18	0.10	0.26	0.52	0.78	1.04	11.23	11.39	11.65	11.91	12.17
10	1.98	4360	2.42	3.34	0.25	0.24	0.20	0.50	0.99	1.49	1.98	6.45	6.75	7.24	7.74	8.23
15	2.90	3420	1.90	2.22	0.48	0.39	0.29	0.73	1.45	2.18	2.90	5.28	5.72	6.44	7.17	7.89
20	3.86	3140	1.74	1.67	0.75	0.46	0.39	0.97	1.93	2.90	3.86	5.01	5.59	6.55	7.52	8.48
25	4.80	3080	1.71	1.33	1.12	0.52	0.48	1.20	2.40	3.60	4.80	5.16	5.88	7.08	8.28	9.48
30	5.74	3140	1.74	1.11	1.60	0.57	0.57	1.44	2.87	4.31	5.74	5.59	6.46	7.89	9.33	10.76
35	6.70	3280	1.82	0.95	2.25	0.63	0.67	1.68	3.35	5.03	6.70	6.32	7.33	9.00	10.68	12.35
40	7.62	3420	1.90	0.83	3.00	0.70	0.76	1.91	3.81	5.72	7.62	7.19	8.34	10.24	12.15	14.05

The figures worked out for total costs are not the actual costs of refining, but simply totals which vary as the actual costs will when the density is varied. In order to find the density which will give the minimum cost for each power cost these results are plotted in Fig. 6.

In Fig. 7 the minima so determined are plotted against the current density and we have established the general relation already shown in Fig. 3 between current density and power cost.

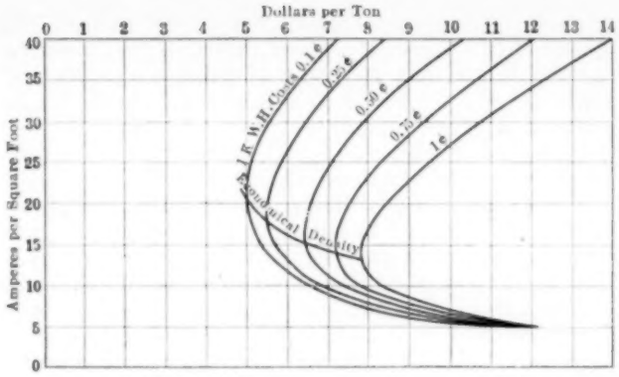

Dollars per Ton
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Amperes per Square Foot
40 35 30 25 20 15 10 5 0
K.W.H. Costs 0.1 ¢
0.25 ¢
0.50 ¢
0.75 ¢
1 ¢
Metallurgical Density

FIG. 6—CURRENT DENSITY VS. VARIATION IN TOTAL OPERATING COSTS

It will be observed that the two curves for theory and practice agree well except at the lower power costs where practice runs at a higher current density than would be expected from our discussion.

This is due largely to the fact that although a certain density may show minimum cost a higher density may show maximum profits. For example suppose that a plant operates with power costing ¼ cent per kilowatt hour at the density for lowest cost shown by our curve in Fig. 7 to be 18 amperes per square foot, and that the profit from refining is pushed up to 25 amperes a square foot the cost by Fig. 6 will be increased about $0.33 a ton and the profit per ton be cut to $2.67; but the increased density will allow the plant to treat 38 per cent more copper so that instead of $3.00 we make an equivalent of 1.38 by $2.67 or about $3.70.

This argument is fallacious where we are designing a plant for a certain tonnage, as our calculations have shown that the $0.33 excess cost would pay more than 20 per cent on the increased investment to bring the density back to 18 amperes per square foot, but practically a plant after being put into operation is crowded by the steady annual growth in the production of copper and we may say is unable to keep up with this demand for capacity by extensions.

On the other hand where power is expensive this process of expansion receives a much earlier check than

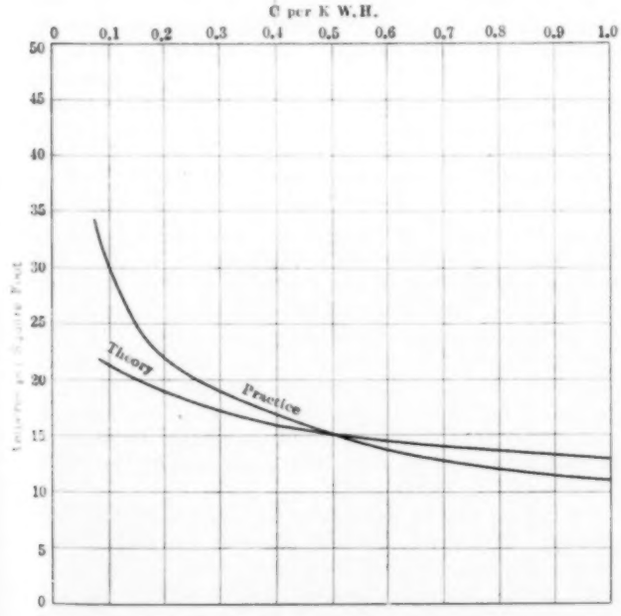


FIG. 7—CURRENT DENSITY VS. POWER COST—THEORY VS. PRACTICE

where it is cheap and this tends to explain at least part of the difference between theory and practice.

Then too at very low power costs we must be considering water power installations and this not only affects the investment factor we have assumed for steam plants, but introduces the question of secondary water power where excess power allowed to run to waste over a dam may be utilized at exceedingly low rates. Also the assumptions of interest rates, price of copper and silver and gold values have to be corrected for each practical case.

The Fixation of Nitrogen as Cyanide

A very interesting lecture was delivered by Prof. John E. Bucher of Brown University, Providence, R. I., on this subject on the afternoon of March 2, at the College of the City of New York. The lecture was one of the regular series of public lectures given by the Chemistry Department of the College. Professor Bucher described in the most vivid manner his experiments on the production of sodium cyanide by passing a current of nitrogen over a mixture of soda ash, coke and iron filings. The lecture covered much the same ground as his recent paper before the American Institute of Chemical Engineers, abstracted in our issue of January 15, page 82. But a fuller account of the work of Professor Bucher in this field should prove particularly interesting to our readers at the present time.

The address was given in the chemical lecture room of the college and Professor Bucher had considerable apparatus set up to show how the various processes described were conducted. The time did not allow of the performing of but one or two experiments, but the apparatus, together with many samples, served to elucidate the description of the processes. After the lecture Professor Bucher answered many questions and explained some of the apparatus in greater detail.

The reactions which were studied by Professor Bucher in his work are not new, and he first took up the history of the subject. Lewis Thompson, in 1839, described in the "Mechanics Magazine" (London) experiments made on the manufacture of cyanide and its conversion into Prussian blue. He ground two parts of pearl-ash, two parts of coke and one part of iron turnings into a coarse powder and heated this in an open crucible to a full red heat for half an hour. He obtained potassium cyanide from this, which he converted into Prussian blue. Particular attention was called by Professor Bucher to the fact that Thompson stated that iron was necessary in the process if it was to be carried out at a moderate temperature. In 1843 Newton took out a patent for the production of cyanide, using atmospheric nitrogen. A factory was built at Newcastle-on-Tyne which produced yellow prussiate of potash for some time, but finally failed in 1847 owing to the non-use of iron and the consequent necessity of operating at a very high temperature.

Victor Alder of Vienna took out patents in Germany In the years 1881 to 1885, in which it was stated that iron could be used but that it was not absolutely necessary to use it, and that the process would work all right without iron. Attempts to work the process according to these patents for several years in Germany finally resulted in failure. Thus the original condition for successful working as originally established by Thompson was overlooked in the practical work following.

Professor Bucher mentioned that he had done work on a magnesium nitride process, forming the nitride from metallic magnesium and nitrogen. This when heated with ammonium chloride gives ammonia and

magnesium chloride. He did not, however, go into this in any detail.

The first experiments discussed were those on the fixation of atmospheric nitrogen with alkali metal according to the equation:

$$2Na + 2C + N_2 = 2NaCN + 46{,}200 \text{ calories.}$$

A ½ in. malleable iron pipe about 30 in. long was inclosed in a larger horizontal pipe so that the inner pipe could be surrounded with hydrogen or nitrogen to prevent diffusion of carbon dioxide into the inner tube. This inner tube was filled with lampblack and heated to a white heat in a current of hydrogen. Sodium was then placed in one end of the tube and nitrogen passed through and allowed to bubble through water in a flask at the other end. If nitrogen is absorbed, then a partial vacuum is created and the water will rise in the tubing toward the iron tube. In the experiments with metallic sodium and lampblack or graphite the water rose very slowly, indicating a slow absorption of the nitrogen. It was found to require hours to get much absorption.

Using the same apparatus and adding finely divided iron to the charge made a marvelous change in the rate of nitrogen absorption. In this case the water backed up so rapidly that there was scarcely time to turn the nitrogen on full force to keep the water from entering the tube and reacting with the sodium. In this case 94 per cent of the sodium was converted into cyanide and fused globules of iron were found in the tube, indicating the strongly exothermic nature of the reaction. The catalytic action of iron was thus seen to be extremely strong.

This experiment led to the testing of this process for the purification or decarbonization of iron. Professor Bucher showed several small hack-saw blades which had been heated in a current of nitrogen and sodium vapor to a dull red heat for several hours. They were very soft and silvery in appearance and could be bent into any shape without breaking. He then reheated one of the blades to a good red heat and quenched it. It still remained soft, thus showing the absence of carbon. He then made one of these blades the anode in a beaker of dilute hydrochloric acid. The blade remained silvery white and no carbon was deposited. On making an untreated blade an anode in the same solution and turning on the current a few minutes, carbon was quickly deposited on the bottom of the beaker. The sodium was stated to remove not only carbon but also phosphorus and sulphur.

The utilization of this reaction for the preparation of carbon-free metallic iron was also discussed in connection with the reversibility of the equation.

$$2NaCN + \text{Iron} \rightleftarrows 2Na + N_2 + \text{Carburized iron.}$$

This is the equation for the case hardening of iron, and when experiments were made with a mixture of sodium cyanide and pure iron powder and heated in an iron tube considerable metallic sodium was found in the colder part of the tube.

The next set of experiments discussed were those in which sodium carbonate was used instead of metallic sodium. In experiments made without the use of iron with a mixture of powdered graphite and sodium carbonate, heated in a ½ in. copper tube at 920 deg. C. in a current of nitrogen, only a very small amount of sodium was formed and no cyanide. The fact that sodium was found, however, indicated that sodium carbonate and carbon do react to give metallic sodium.

Following these experiments, tests were made using mixtures of graphite, iron and sodium carbonate and heating in the ½ in. tube in a current of nitrogen at 920-940 deg. C., as before. In this case the product gave 60 per cent of the sodium carbonate converted into cyanide. These experiments with iron showed that Thompson's original statement that iron was necessary is correct and that the cause of failure of subsequent work was the neglect of this condition. From the results of a large number of tests on pipes of many lengths and diameters, it was found that 2-in. pipes 10 ft. long were the most efficient.

The inconvenience of using powder led to the development of a system of briquetting, in which advantage is taken of the solubility relations of sodium carbonate. Hot water is added to the mixed charge of coke, soda ash, and iron. The maximum temperature of a sodium carbonate solution is 104.75 deg. C. The percentage of carbonate (about 30 per cent) in the solution does not change much until the temperature is lowered to about 35 deg. Then $Na_2CO_3 \cdot 10\ H_2O$ crystallizes out rapidly down to about 12 per cent Na_2CO_3 at 10 deg. The mass is mixed with the water at as near the maximum temperature as convenient, thus giving a range of 70 deg. C. through which the mass might cool before the water would be taken up by the crystals to form the dry hydrate, $Na_2CO_3\ 10\ H_2O$. Many tons of briquets were made in this manner. At first an ordinary concrete mixer without steam jacket was used, but later a steam-jacketed kneading machine was found more convenient. Small briquets were made from the hot mixture by a small meat chopper, such as found in every household. One of these will produce 5000 lb. of briquets in 24 hours. The briquets should be dried rapidly so as to get them hard. Hot waste gases are good for this purpose. On a commercial scale, iron scale was used and ground to 100 mesh in a ball mill. One hundred mesh coke was then added and then soda ash. With these briquets charges were put through which ran 28 per cent NaCN when finished.

Experiments were then made to determine the percentage of soda ash which would give maximum commercial efficiency and not cover the catalytic iron surface so as to render it sluggish. Three tests were made with the iron-coke-soda ratios 2 : 2 : 1, 1 : 1 : 1, and 1 : 1 : 2, respectively. These experiments showed that the 20 per cent soda ash briquets were the most reactive and that the reaction diminished as the soda ash was increased beyond that point. Also a higher temperature is required for the higher soda ash content.

In conducting experiments with the tube horizontal it was found that the briquets often sagged, forming a channel over the charge. The nitrogen upon being introduced quickly found this channel, and consequently there was little conversion to cyanide. This difficulty was overcome by placing the retorts or tubes vertically.

In connection with the question of loss of alkali by volatilization, experiments were made with continuous oil-burning furnaces with continuous feed of the charge in at the top and continuous withdrawal by conveyor at the bottom. Trouble was experienced by the plastic briquets hardening in the conveyor so that it could not be turned. The reaction tube was made longer so that the worm conveyor could be placed about 4 ft. below the bottom of the furnace. This gave the briquets a chance to cool and they passed through the conveyor all right. They stuck to the pipe, however, in descending, and consequently it was found advisable to use an enlarged section of pipe for the lower end of the furnace, or to cool this lower end.

In taking up the discussion of electric heating of the charge, Professor Bucher showed several tubes in which electric heating had been done. The first one with which he experimented was a section of 1½-in. galvanized iron pipe about 3 ft. long and with copper hands on each end. In electrical heating a resistor outside the tube may be used, the tube itself may be used

as resistor, or the charge may be used as resistor. Professor Bucher says the ideal way to heat the charge if it is done electrically would be to use the charge itself as resistor. With the above-mentioned galvanized iron pipe as resistor and furnace combined, a test was made with the pipe surrounded with magnesia asbestos to prevent oxidation. The zinc rapidly burned off the furnace, when the current was turned on, but the test worked satisfactorily and the resulting briquets gave 22 per cent sodium cyanide.

With an apparatus rigged up with a 15-kw. welding machine in place of a transformer and using a 4-in. iron pipe 6 ft. long as the resistor and furnace combined, charges were put through which gave 25 per cent NaCN consistently. Professor Bucher had one of these welding machines on exhibit. Vertical iron wires surrounding the furnace and suitably spaced from each other have also proven successful as resistors when properly protected from oxidation. Professor Bucher had a set of these wires connected up and showed how they heated up with the current on. The resistance increase could be plainly seen from a large ammeter on the wall as the current dropped on rise of temperature.

An interesting experiment was described with molten iron as follows: A cylindrical electric furnace with a bottom like a Bessemer converter contained molten iron and coke fragments pressed down from the top by the top electrode. Sodium vapor and nitrogen were blown in at the bottom and cyanide distils out at the top. The only drawback is the necessity of ashless carbon.

Air may be used instead of nitrogen by first passing it over hot coke and fixing the oxygen as carbon monoxide. The coke may be placed as a layer in the furnace with the briquets. Similarly, producer gas could also be used. Experiments with air were entirely successful.

Distillation in a copper tube at 1000 deg. C. and 2 mm. pressure gave good results. The great promise of this method is threatened by the ash from the coke accumulating with each repetition until it stops the process. Ashless carbon is, therefore, necessary. It was thought that the reaction $2CO \rightleftarrows C + CO_2 + 38{,}080$ calories might be taken advantage of. At 1050 deg. C. this reaction gives almost pure CO, while at 500 deg. C. it is almost reversed.

Experiments along this line brought out the fact that with iron as a catalyser the reaction proceeded with the formation of C and CO_2 with great rapidity. It gives ashless carbon in the form of lampblack and also 38,080 calories of heat.

With electrical heating the oxidation of the iron pipe is prevented by keeping oxygen away from the outside of the pipe. With fuel-heating the problem of oxidation must be seriously considered. Thousands of experiments have shown, however, that no difficulty need be experienced from this source if proper recognition is given to the proportions of CO and CO_2 present. If producer gas is used, hydrogen might be admitted with the gas. Copper tubes would also avoid oxidation and nickel sheathing has also held out some promise.

Among the various compounds which can be made from the cyanide is sodium ferrocyanide, which can be made by adding hot water to the cyanized briquets to make a stiff paste and then steaming them in an agitator for several hours. The mass is then filtered and the black powder turned into the process again. The filtrate deposits ferrocyanide crystals out on cooling.

By adding caustic soda to the sodium cyanide solution and boiling, ammonia and sodium formate are successfully made. Other products mentioned by Professor Bucher as offering possibilities are urea and oxamid.

Salt Manufacture by Solar Evaporation of Sea Water

By Leroy A. Palmer

The operations of the Western Salt Company at the south end of San Diego Bay in Southern California are typical of present-day practice in the refining of high-grade salt by solar evaporation.

NATURAL CONDITIONS

The source of supply is the water of San Diego Bay, a long and narrow land-locked arm of the Pacific Ocean. The bay has a very narrow entrance situated at the extreme northern end, so that the water does not change completely with each ebb and flow of the tide. This condition, together with the facts that the inflow of fresh water is small and the evaporation high, tends to a natural concentration of the solids, so that the proportion in the water at the southerly end of the bay, where the plant is situated, is somewhat higher than in the ocean water.

Detailed analyses of the water of San Diego Bay are not available, but some samples run for sodium chloride have shown as high as 4 to 5 per cent NaCl.

Two analyses of the ocean water gave the following results:

Substance.	Per Cent.	
Na Cl	2.67	2.70
$Mg\ Cl_2$	0.322	0.360
$Mg\ SO_4$	0.197	0.230
K Cl	0.129	0.070
$Ca\ SO_4$	0.163	0.140
Na Br	0.042	
$Ca\ CO_3$	0.017	0.003
$Mg\ Br_2$		0.002
$Na_2\ CO_3$	0.014	
$Fe_2\ O_3$	0.003	
Na I (or Mg I)	0.0024	
Other solids	0.004	0.025

In the manufacture of salt by this process the amounts of evaporation and precipitation will, of course, play an important part, the former promoting and the latter retarding the crystallizing of the salt from the water. The site chosen for the location of the plant is such as to give a net annual evaporation of 50 in., a total evaporation of 60 in. against an average precipitation of 10.01 in.

POND SYSTEM

This company was seriously damaged by the heavy floods of January, 1916, and has not yet gotten back tc its former equipment or scale of operations. In the following description the practice as indicated by the number and area of the ponds is not strictly in accord-

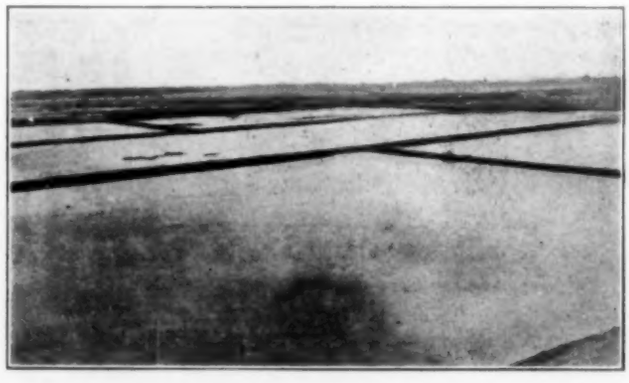


FIG. 1—EVAPORATION PONDS ON SAN DIEGO BAY

ance with present methods but pertains rather to those followed prior to the flood and which will closely approximate those to be used when damaged dikes can be repaired and other changes made.

The first step in the process is the admission of the bay water to the tide ponds. There are four tide ponds, having a total area of 250 acres, three of them equipped with 16 ft. and one with 8 ft. tide gates. The ponds are surrounded by a levee 10.5 ft. high and three miles long. The water is admitted at high tide, which reaches an average maximum of 7.4 ft. The density* of the bay water as admitted is 17 deg. salometer (4.4 deg. B.). The water is retained in the tide ponds until the next high tide, two weeks, just preceding which it is transferred by pumping.

Pumping is by two centrifugal pumps, operating in parallel by direct connection to a 50 hp. motor. The combined capacity is 15,000 gal. per minute. Each pump has a 36 in. suction and a 24 in. discharge, the two discharge pipes uniting in one main 36 in. line. By this means the water is lifted eight feet to a sump, from which it flows to the high point of the secondary ponds, among which it is distributed by means of gates between the ponds. These secondary ponds, shown in Fig. 1, are nine in number and have a total area of 333 acres.

At the end of two weeks, time for another flow to the tide ponds, the water has reached a density of about 26 deg. S. (6.77 deg. B.), and is concentrated in the lower secondary ponds to make room in the upper ponds for another pump run.

Evaporation is continued further in the secondary ponds until a density of 36 deg. S. (9.26 deg. B.) is reached. The secondary ponds are sometimes referred to as the "lime ponds," as the calcium carbonate deposits from the brine and settles to the floor of the pond at about 30 deg. S. (7.82 deg. B.).

From the last of the secondary ponds the brine is run to the pickling pond, which has an area of 112 acres. Here evaporation is continued until the brine has a density of 100 deg. S. (24.1 deg. B.). Gypsum (calcium sulphate) commences to settle out at 55 deg. S. (13.78 deg. B.) and is practically all thrown down by the time the density reaches 100 deg. S.

When this density is reached the brine is drained to the crystallizing pond of 51 acres, and at 106 deg. S. (25.2 deg. B.) the salt commences to deposit.

As stated, the net annual evaporation on San Diego Bay is approximately 50 in. The density of the water in the crystallizing ponds is such that one inch of salt is thrown down for each six to seven inches of evaporation, so that the annual deposit of salt is from seven to eight inches. As one acre inch of salt weighs approximately 110 tons, this gives a crop of 770 to 880 tons per acre. It has been found that a depth of six to eight inches allows of the most economical harvesting.

Evaporation is continued in the crystallizing ponds to a density of 130 deg. S. (29.67 deg. B.), and the brine then transferred to the bittern ponds. Up to 132 deg. S. (30 deg. B.) the sodium chloride will crystallize out pure with the exception of a small amount of magnesium chloride, but above 132 deg. other salts will deposit, magnesium sulphate being the first to be thrown down.

When the brine is drawn off from the crystallizing ponds, the salt remains as an incrustation, showing typical isometric crystals characteristic of halite, Fig. 2. Many of these crystals are large, an inch or more in diameter, and exhibit a beautiful rose pink color due to the presence of magnesium chloride.

HARVESTING AND WASHING

Harvesting is usually commenced the latter part of August and continued until the latter part of November. It has been found that the most economical practice is to use the rather primitive method of hand shovelling, as this prevents cutting too deeply and bringing up impurities with the salt.

The crystallized salt is shovelled to small two way dump cars on 36 in. tracks, which can be shifted from time to time to keep them within easy reach of the shovellers. The train of cars is hauled out of the crystallizing pond by a gasoline locomotive and dumped to a shallow bin. The bin is V shaped, 100 ft. long, 4 ft. wide, with sloping sides, and 4 ft. deep. It is provided with 31 rack and pinion gates in the bottom, operated from above by hand wheels, by means of which the salt is discharged through the bottom to a screw conveyor, which works it to a belt elevator.

The elevator raises the salt 10 ft. and dumps it to the washer, which is simply a box or trough 30 ft. long, 2 ft. wide and 4 ft. deep, with a screw conveyor in the bottom. The washing is accomplished by working the salt through this trough by means of the screw conveyor against a current of a density of 50 deg. S. (12.5 deg. B.), which is pumped from the pickling pond. The trough is kept full of the brine, which flows back to the pond after passing through. During the process the density of the wash water is increased to 100 deg. S. by the salts which it dissolves. This wash water is raised from the pickling pond by a 3 in. centrifugal pump and delivered to a small pond near the washer, from which a 5 in. centrifugal raises it to the washer.

The screw from the washer delivers the salt to a bucket elevator running on an angle of 45 deg. with a vertical lift of 50 ft. Near the boot of the elevator it

*The figures for density given in this article, both in salometer degrees and in Baume degrees, were supplied by the company. While the usual salometer scale gives directly the percentage of salt in solution, a different salometer scale is used, the idea being evidently to get a wider range of figures and permit greater accuracy.

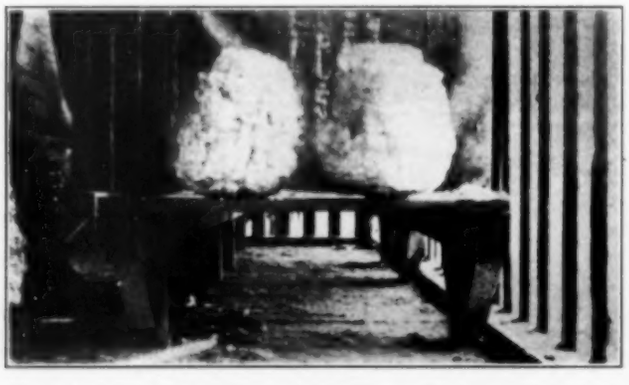


FIG. 2—SALT SHOWING ISOMETRIC CRYSTALS AS DEPOSITED

FIG. 3—TRESTLE AND STOCK PILES

receives a final brine washing by a drip from the pump line and as it is elevated it passes under two perforated pipes, which spray it with fresh water. This removes any dirt or mother liquor which may have escaped the previous washing and precipitates any gypsum which may have remained, so that the dried product analyzes 99.823 per cent Na Cl. The small amount of impurities which does remain consists of sulphates of calcium, magnesium and sodium and chlorides of calcium and magnesium.

STACKING AND SHIPPING

The elevator described dumps the salt to a semi-circular trough with bottom gates carried on a trestle. A screw works in this trough so that by opening the proper gate the salt may be discharged at any desired point to the stock piles shown in Fig. 3.

The salt is thus stacked in piles 50 ft. high and allowed to dry in the air, by which process the moisture content is reduced to 1½ to 3 per cent. Under the platform supporting the stock piles are horizontal screw conveyors so that, as the salt is picked down by hand, it is carried along to the boot of a scraper elevator. This elevator runs at an angle of 45 deg. and delivers to a short screw, which feeds a 4 x 12 ft. hexagonal trommel with a ⅜ in. wire screen.

Oversize and undersize of the trommel run to spouts and thence to 50 lb. sacks, which are automatically weighed, sewed and tossed to a short belt conveyor, by which they are delivered either to the shipping platform or boxcars. Elevating, sacking and weighing machinery are mounted on trucks on a 6 ft. track running parallel to the stock pile, so that they may always be convenient to that part of the pile which is being shipped.

The annual output of the plant is from 30,000 to 40,000 tons.

POSSIBLE BY-PRODUCTS

The bittern water, the drainings of the crystallizing pond, which is now going to waste, contains compounds from which valuable by-products could be obtained.

An analysis of this water shows total solids of 28.86 per cent, as follows:

$MgCl_2$	9.10
$MgSO_4$	5.60
Na Cl	12.06
K, Br, etc.	2.10

Sp. G.=1.2608. Weight per gallon=10.51 lbs.

The magnesium chloride is the most important constituent of the bittern water, forming as it does 31.5 per cent of the total solids. Prior to the floods mentioned the Magnesium Products Company operated a plant adjacent to the salt ponds and bought the bittern water on contract. Its principal products were magnesium chloride and magnesium sulphate (epsom salts). Unfortunately this plant was almost directly in line with the flood and was a total wreck. It has not been rebuilt and the Western Salt Company is now desirous of making another contract of a similar nature by which this waste may be utilized.

San Francisco, Cal.

Chemical and Physical Research in Norway.—The "Norsk hydroelektrisk Kvaelstof aktieselskab" has set aside 100,000 kr. to be transferred to the Nansen fund trustees, Christiania, Norway, for the promotion of chemical and physical research. Inasmuch as the founder of this company, Sam Eyde, celebrated his fiftieth birthday on Oct. 29, 1916, the company desires that this fund shall be designated as "The Sam Eyde fund for the promotion of chemical and physical research."

The Analysis of Nickel Chromium Alloys

By Emil D. Koepping

The sample, if a fair-sized piece, is prepared for analysis by drilling in the usual manner. If it is in the form of wire it should first be cleaned with emery cloth and then wiped with a clean cloth saturated with alcohol. The wire is then cut into very short lengths.

SILICON

Weigh out 2 g. of the sample and transfer to a casserole. Add 10 c.c. of water, and 25 c.c. of a mixture of 1 part of nitric acid and 4 parts of hydrochloric acid. Place on the hot plate and heat until solution is complete. When completely dissolved remove from the hot plate and add half a gram of potassium chlorate. Replace on the hot plate and evaporate to dryness. Cool; take up in 30 c.c. of hydrochloric acid and again evaporate to dryness and bake. Cool; take up with 10 c.c. of hydrochloric acid and 100 c.c. of water. Boil for 5 minutes. Filter through an ashless filter paper using suction. Catch the filtrate in a clean beaker. Wash alternately with hot water and hot 3 per cent hydrochloric acid several times, then with water alone several times. Suck dry. Place the filter in a platinum crucible and burn off the paper over a low flame. Ignite strongly, using a blast lamp or Meker burner. Cool in a dessicator and weigh. Treat the residue with a drop or two of nitric acid and about 1 c.c. of hydrofluoric acid. Evaporate the acids on the hot plate or over a very low flame. Ignite strongly, cool and weigh as before. The loss in weight is silica. From this calculate the silicon.

NICKEL

The filtrate from the silicon determination is diluted to one liter in a volumetric flask. A 100 c.c. portion (= 0.2 g.) is measured off, using either a volumetric flask or an accurate pipette, and transferred to a 600 c.c. beaker and diluted to 300 c.c. About 10 g. of powdered citric acid is then added to the solution and dissolved. Neutralize the solution with ammonia and then acidify with 1 c.c. of acetic acid. Heat to boiling and add 1 g. of dimethylglyoxime which has been dissolved in about 100 c.c. of alcohol by warming. Then add ammonia dropwise while stirring until the solution smells slightly of ammonia. The nickel will then have been precipitated as nickel dimethylglyoxime. Allow the solution to stand on a cooler portion of the hot plate for about 10 minutes, stirring occasionally. Filter the hot solution through a Gooch crucible which has been dried at 110-120 deg. C. and weighed. Wash with hot water and dry for 45 minutes at 110-120 deg. C.; cool and weigh. The nickel dimethylglyoxime is red and crystalline. It contains no water of crystallization and sublimes at 250 deg. C. without decomposition. Consequently it should not be heated too long or too hot. It contains 20.316 per cent of nickel.

If a duplicate determination of the nickel is desired, weigh out 0.2 g. of the sample. Place in a 600 c.c. beaker and dissolve in 10 c.c. of hydrochloric acid and 10 c.c. of water, add 5 c.c. of nitric acid and 10 c.c. of sulfuric acid. Evaporate over a free flame until the solution smells sweet. Cool, dilute to 100 c.c. and filter off the silica. Dilute the filtrate to 300 c.c. and proceed as before.

CHROMIUM

Measure off 200 c.c. (= 0.4 g.) of the filtrate from the silicon determination, transfer to a 600 c.c. beaker, add 10 c.c. of sulfuric acid and evaporate until the solution smells sweet. Cool, dilute with a little water and evaporate again to be sure that all hydrochloric acid has been removed. Cool; dilute with 50 c.c. of water;

add 60 c.c. of dilute nitric acid (sp. gr. 1.2, 3 parts of conc. nitric acid to 4 parts of water) and boil two minutes. Then dilute with 200 c.c. of hot water and when boiling add a strong permanganate solution a little at a time until a slight precipitate of manganese dioxide is formed that does not dissolve on boiling. The solution should have a reddish color from undecomposed permanganate after 5 minutes boiling. Decompose the excess permanganate with a little manganese sulfate solution and cool. Filter through an asbestos matt and wash with dilute sulfuric acid (one part conc. acid to three parts of water). The volume of the solution, which is now ready for titration, should be about 350 c.c. Add a measured excess of N/10 ferrous sulfate solution and titrate back with N/10 permanganate solution with constant stirring until a pink tint is obtained which persists for at least 1 minute.

The permanganate solution should be standardized against sodium oxalate (Sörensen's) in the usual manner. The iron value so obtained multiplied by 0.3103 gives the chromium value of the permanganate. The ferrous sulfate should then be titrated with permanganate in an acid solution which has been treated just as if it were a sample. Finally the ferrous sulfate should be titrated with permanganate in a solution containing about the same amount of nickel and iron as the sample, but free from chromium, and which has been treated exactly as if it were a sample. The amount of permanganate necessary to produce the pink tint over and above that required in the titration when the acids alone were present is to be subtracted from the permanganate used.

If a duplicate determination is desired, dissolve 0.4 g. of the sample in 10 c.c. of hydrochloric acid and 10 c.c. of water. Add 10 c.c. of sulfuric acid and evaporate until sweet as before and proceed as above.

MANGANESE

Weigh out 1 g. of the sample and transfer to a beaker. Dissolve in 20 c.c. of hydrochloric acid, 5 c.c. of nitric acid and 20 c.c. of water. When solution is complete cool somewhat and add 10 c.c. of sulfuric acid. Evaporate until the solution smells sweet. Cool and dilute with water. Add strong sodium hydroxide solution until a permanent precipitate appears. Dissolve the precipitate with a few drops of sulfuric acid and cool to room temperature. Transfer the solution to a 500 c.c. volumetric flask and add zinc sulfate solution equivalent to 10 g. of the crystallized sulfate and 1 g. of zinc oxide. Dilute to the mark and shake. Allow to settle and decant 250 c.c. (= 0.5 g.) through a dry filter catching the filtrate in a volumetric flask. Transfer to a beaker and heat to boiling. Titrate slowly with N/10 permanganate solution with constant stirring until the pink color of the permanganate appears in the solution. Then add 1 c.c. of glacial acetic acid and boil. The pink color will be discharged owing, apparently, to the liberation of absorbed manganous salt from the precipitate, which now becomes flocculent and settles. The solution is again titrated until the pink color is restored. The total volume of permanganate used is taken as that required to react with the manganese present.

If the sample proves to be low in manganese a large enough sample should be taken so that at least 5 or 6 mg. of manganese are present in the liquid which is to be titrated.

IRON

Measure off 100 c.c. (= 0.2 g.; or any other suitable aliquot part which does not represent over 0.05 g. Fe) of the filtrate from the silicon determination and neutralize with sodium carbonate solution until a permanent precipitate forms. Redissolve the precipitate with 1-1 hydrochloric acid, adding a drop at a time and allowing each drop two or three minutes to act. When clear add 1 g. of ammonium acetate and dilute to 300 c.c. Heat to boiling and boil vigorously for ten minutes. Allow to settle and filter, washing once with hot water. Redissolve the precipitate in hot 1-1 hydrochloric acid, neutralize with sodium carbonate and repeat the basic acetate separation as above. Dissolve the precipitate from the filter in hot 1-1 hydrochloric acid and wash the filter well with hot water. Neutralize the solution with potassium hydroxide solution and add an excess. Dilute the solution to 200 c.c. and boil 5 minutes. Set on a cooler part of the hot plate to settle. Filter into a clean beaker and wash the precipitate with hot water. Set the filtrate aside for the determination of aluminum. Dissolve the precipitate of ferric hydroxide from the filter in hot 1-1 hydrochloric acid and wash the filter several times with hot water. Evaporate the solution to small bulk (about 5 c.c.). From a dropping bottle add stannous chloride solution (prepared by dissolving 250 g. of stannous chloride in 100 c.c. of concentrated hydrochloric acid and diluting to one liter) until the solution becomes colorless. Dilute with 100 c.c. of cold distilled water and pour into 400 c.c. of water containing 20 c.c. of a saturated solution of pure mercuric chloride in water. A slight silky precipitate of mercurous chloride should form. 30 c.c. of "titrating" or "guard" solution are now added and the solution is titrated to the appearance of a pink color which permeates the entire solution and is permanent for 30 seconds.

The "guard" solution is prepared as follows: 67 g. of crystallized manganese sulfate are dissolved in 500 c.c. of water; 138 c.c. of syrupy phosphoric acid (sp. gr. 1.7) and 130 c.c. of concentrated sulfuric acid are then added, and the mixture is diluted to one liter.

ALUMINIUM

The caustic potash filtrate from the separation of iron and aluminium is acidified with hydrochloric acid. Add 15 c.c. of a saturated solution of sodium phosphate and then ammonia with constant stirring until a slight permanent precipitate forms. Now add 5 drops of hydrochloric acid. This should dissolve the precipitate and leave the solution clear. Then add with constant stirring 20 c.c. of a saturated solution of sodium thiosulfate. Cover the beaker and heat to boiling, and when boiling add 20 c.c. of a solution prepared by dissolving 100 g. of sodium acetate in 200 c.c. of acetic acid (sp. gr. 1.04) and diluting to 500 c.c. Boil the solution 10 minutes. Allow to settle, filter through an ashless paper and wash thoroughly with hot water. Place the filter and precipitate in a weighed porcelain crucible and dry. Ignite at a low heat until the paper has burned off and then ignite over the blast lamp or a Meker burner.

Cool in a dessicator and weigh as $AlPO_4$. The precipitate after ignition should be white.

SULFUR

Fuse 2 g. of the sample with 15 g. of sodium peroxide in a nickel crucible. The heat should be applied very slowly. An alcohol lamp, gasoline, gas or electric heat should be used as the sulfur in ordinary gas is liable to vitiate the result. As soon as the fusion is liquid raise the heat for a few minutes and then allow to cool. Place the crucible on its side in a beaker and cover with a watch glass. Add about 30 c.c. of water and when the violent action is over remove the crucible and wash it. Dilute the solution to 200 c.c. and filter from it the insoluble ferric oxide, nickel oxide, etc., and wash with water containing a little sodium carbonate. Acidify the

filtrate with hydrochloric acid and evaporate to dryness in a casserole and bake. Cool; add 20 c.c. of hydrochloric acid and heat until all soluble salts dissolve. Dilute with hot water, filter, and wash with hot water. Neutralize the filtrate with ammonia and acidify with 1 c.c. of hydrochloric acid. Heat to boiling and add 10 c.c. of a boiling 10 per cent solution of barium chloride. Boil for a few minutes. Allow the solution to stand over night, preferably in a warm place, filter through a Gooch crucible which has been ignited, cooled and weighed, wash thoroughly, dry, ignite at a dull red for 10 minutes, cool and weigh. Calculate the barium sulfate to sulfur.

PHOSPHORUS

Fuse 2 g. of the sample with 15 g. of sodium peroxide in a nickel crucible. Dissolve the fusion in water as under "Sulfur." Dilute to 200 c.c. and filter. Wash with water containing a little sodium carbonate. Acidify the filtrate with nitric acid, heat to expel carbon dioxide, add a little ferric chloride solution, add ammonia until the solution is alkaline to litmus paper and then acidify with acetic acid. Boil for a few minutes, filter, wash the precipitated ferric phosphate and hydrate with hot water. Dissolve the precipitate in hot 1-1 hydrochloric acid and evaporate to dryness. Redissolve in 1 c.c. of hydrochloric acid, dilute and filter off the silica. Evaporate to small bulk, and drive off the hydrochloric acid with nitric acid. Transfer the nitric acid solution to a flask, add 5 g. of ammonium nitrate and dilute to 50 c.c. Heat to 80 deg. C. and add 50 c.c. of molybdic acid solution while rotating the solution in the flask. Shake for two or three minutes and allow to stand one hour. Filter and wash with ammonium nitrate solution (5 g. per liter). Dissolve the precipitate in 10 c.c. of dilute ammonia (8 per cent), add 5 g. of ammonium nitrate, dilute to 50 c.c., heat to 80 deg. C. and reprecipitate by adding 20 c.c. of nitric acid while rotating the solution as before. Agitate for a minute or two and allow to stand one hour. Filter and wash with ammonium nitrate water as before, or with water until neutral if the precipitate is to be titrated.

The phosphorus may now be determined in the "yellow precipitate" either volumetrically by dissolving in an excess of standard sodium hydroxide solution and titrating the excess with standard nitric acid using phenolphthalein as indicator or the "yellow precipitate" may be redissolved in ammonia and the phosphorus determined as follows: The solution is neutralized with nitric acid until the yellow precipitate formed dissolves only slowly on being mixed with the solution. 10 g. of ammonium chloride are then added and the solution is heated to boiling. 10 c.c. of magnesia solution are then added dropwise followed by one-third the solution's volume of 10 per cent ammonia. After standing two or three hours the solution is filtered through a Gooch crucible, which has been ignited and weighed, and the precipitate is washed with 2 per cent ammonia water. The crucible and precipitate is dried, placed inside a larger porcelain crucible and heated gradually up to a bright red. The magnesium pyrophosphate thus formed should be white or very nearly so. The crucible is cooled in a dessicator and weighed. The magnesium pyrophosphate found is calculated to phosphorus.

CARBON

Carbon is best determined by burning a sample of the drillings, after mixing with an equal quantity of red lead, the "blank" of which is known, in oxygen and absorbing and weighing the carbon dioxide formed.

Lockport, N. Y.

Plastic Cements*

By J. B. Barnitt

A working knowledge of the correct mixtures and proper application of plastic cements is deemed so essential to successful chemical engineering operations that an effort has been made to collect and classify a few of the more valuable formulæ and suggestions gained both from experience and current literature.

It is to be understood that plastic cements cover that range of adhesives which are used to secure joints and connections between like or unlike material and which are of more or less permanent character. Physically speaking, plastic cements consist of a vehicle in which are suspended or dissolved solids of such nature that they are resistant to the gases and liquids coming in contact with them. In some cases the constituents of the cement react with each other or with the surfaces to which they are applied, thus forming a more strongly adhering mass. The prime object being in all instances to effect a joint of maximum strength, and in nearly all cases gas tight, a few general instructions on the application of plastic cements are first given. It is, of course, rather an exaggeration to base the success or failure of a process upon the choice of proper cements used in the mechanical construction of apparatus necessary, but it must be conceded that great annoyance has been experienced in manufacturing operations wherein unsuitable compounds were used. This is especially true with such corrosive gases as hydrochloric, chlorine, nitric, sulfuric and sulfurous, bromine, hydrogen sulfide, etc., from which considerable damage to property and loss of life have frequently resulted.

One of the principal precautions to be observed in the application of a cement is the condition of the material to be joined. All connections should be properly fitted together with flanges or exposed flat surfaces as nearly coincident as possible. The cement should never be depended upon to do what the pipes or other portions of the apparatus should do. Its function is to cement or seal and nothing more. In most cases one part of the fitting should overlap the other so as to make a small amount of the cement effective. Cement for a joint of this type should be of a nature that may be quickly applied, that is effective while in place and easily removed when desired. An excess of cement should always be avoided to prevent shrinkage, cracks and leaks.

The general methods of plastic cement application are varied to suit special cases as follows:

(a) Heating the composition to make it plastic until firmly fixed in place.

(b) Heat applied to the surface to be cemented.

(c) Application of the cement with water or a volatile solvent, depending upon the evaporation of the solvent for drying or setting.

(d) Moistening the surfaces to be cemented with water, oil, etc. (The vehicle of the cement itself.)

(e) Application of the cement in workable condition, setting taking place by: (1) chemical reaction, (2) hydration, (3) oxidation.

The application of the following materials as plastic cements is noted: (1) plaster of paris; (2) hydraulic cement; (3) clay; (4) lime; (5) asphalt or pitch; (6) rosin; (7) rubber; (8) linseed oil; (9) casein and albumen; (10) silicate of soda and oxychloride cement; (11) flour and starch; (12) miscellaneous materials.

(1) PLASTER OF PARIS

Plaster of paris is often used alone as a paste for joints on gas and wood distillation retorts and similar

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places where rapidity of setting is a requisite. In order to impart strength, a fibrous material such as asbestos is often mixed with it. Shavings, straw, hair and cloth are frequently used as binders, when a high temperature is not required, while stone, glass and various mineral substances are used as fillers. The following cements are particularly suitable for oil vapors and hydrocarbon gases:

(a) Plaster and water.
(b) Wet plaster and asbestos.
(c) Wet plaster and straw.
(d) Wet plaster and plush trimmings.
(e) Wet plaster and hair.
(f) Wet plaster and brokenstone.

(2) HYDRAULIC CEMENT

Cement is used either alone or with sand, asbestos, etc., and is especially resistant to nitric acid. When used with rosin or sulfur it is employed as a filler rather than for any powers of setting by hydration:

(a) Cement alone.
(b) Cement and asbestos.
(c) Cement and sand.

(3) CLAY

This frequently enters into the composition of plastic cement as a filler. The finely divided condition of the material gives body to a liquid such as linseed oil which, unless stiffened, would be pervious to a gas, the clay being inert.

(a) Clay and linseed oil is suitable for steam.
(b) Clay, linseed oil and fire clay for chlorine gas.
(c) Clay and molasses for oil vapors.

(4) LIME

Caustic lime and linseed oil mixtures are used as a putty. Chalk or china clay frequently replace part of the lime, but enough lime should remain to maintain the caustic property necessary to the formation of a certain amount of lime soap. Silicate and casein compositions also contain lime:

(a) Lime and boiled linseed oil to a stiff mass.
(b) Lime, clay, etc., and boiled linseed oil to a stiff mass.

(5) ASPHALT AND PITCH

Asphalt and pitch are used interchangeably in plastic cements, pitch making the stronger binder. Tar is of less value on account of the light oils and water contained in it. Asphalt in benzol is useful as an adhesive for uniting glass for photographic and microscopical uses, also for coating wood, concrete, brick work, steel, etc., where the melted asphalt would be too thick to apply readily. Benzol is the cheapest and most satisfactory solvent. For waterproofing, melted asphalt with a small amount of paraffin added, and in particular cases boiled oil, is used:

(a) Refined lake asphalt.
(b) Asphalt, 4 parts; paraffine, 1 part.
(c) Asphalt, 10 parts; paraffine, 2 parts; boiled oil, 1 part.

Any of the above may be thinned with hot benzol or toluol.

(d) Pitch, 8 parts; rosin, 6 parts; wax, 1 part; plaster, ¼ to ½ part.
(e) Pitch, 8 parts; rosin, 7 parts; sulfur, 2 parts; stonepowder, 1 part.

Compositions (d) and (e) are used to unite slate slabs and stoneware for engineering and chemical purposes. Various rosin and pitch mixtures are also used, the proportions determined by the consistency desired. Sulfur chemically prevents the formation of cracks while stonepowder acts in like manner mechanically. If acid vapors or corrosive gases come in contact with the cement, limestone should not be the powder used, otherwise it is best. Wax prevents the composition from becoming brittle.

Plastic cements for calking must be both tough and elastic and have the added property of expanding and contracting with the joint to which they are applied:

(f) Pitch, 3 parts; shellac, 2 parts; pure crude rubber, 1 part.
(g) Pitch, 1 part; shellac, 1 part; rubber substitute, 1 part.

(f) and (g) are mixed by melting over a burner.

(6) ROSIN, SHELLAC AND WAX

A strong stone cement having little body and applied in layers.

(a) Rosin, 8 parts; wax, 1 part; turpentine, 1 part. For nitric and hydrochloric acid vapors.
(b) Rosin, 1 part; sulfur, 1 part; fire-clay, 2 parts. Sulfur gives great hardness and permanency in rosin cements.

Good waterproofing cements are:

(c) Rosin, 1 part; wax, 1 part; powdered stone, 2 parts.
(d) Shellac, 5 parts; wax, 1 part; turpentine, 1 part; chalk, 8 to 10 parts.

For a soft airtight paste for ground glass surfaces:

(e) Wax, 1 part; vaseline, 1 part.

A strong cement without body for metals (not copper), porcelain and glass.

(f) Powdered shellac, 1 part; ammonia water, 10 parts. Allow to stand until solution is effected.

(7) RUBBER

Because of its toughness, elasticity and resistance to alterative influences, rubber is a very useful cement.

As a leather cement:

(a) Asphalt, 1 part; rosin, 1 part; gutta percha, 4 parts; carbon disulfide, 20 parts.

As a resistant to acid vapors:

(b) Rubber, 1 part; linseed oil, 2 parts; fireclay, 3 parts.

A plain rubber cement:

(c) Cut crude rubber in small pieces and then add carbon disulfide or benzol, allowing the rubber to dissolve.

Corks and wood are made impervious to water by soaking them in the above solution.

(8) LINSEED OIL

Linseed oil is one of the most generally useful materials for cementing purposes.

For aqueous vapors:

(a) China clay and linseed oil.
(b) Lime and linseed oil, forming the well known putty.
(c) Red or white lead and linseed oil.

The above mixtures become very strong when set and are best diluted with powdered glass, clay or graphite.

(d) Oxide of iron and linseed oil.

(9) CASEIN, ALBUMEN AND GLUE

Cements of this nature, if properly made, become very tough and tenacious, are resistant to moderate heat and oil vapors but not acid fumes.

(a) Finely powdered casein, 12 parts; fresh slaked lime, 50 parts; fine sand, 50 parts, and enough water to make a thick mass.

A strong cement for ground unions standing a moderate heat:

(b) Casein in fine powder, 1 part; rubbed with silicate of soda, 3 parts.

(c) White of egg made into a paste with slaked lime. This should be used immediately after being made up.

A composition for soaking corks, wood packing, etc., to render impervious to oil vapors:

(d) Gelatine, 2 parts; glycerine, 1 part; water, 6 parts.

(10) SILICATE AND OXYCHLORIDE CEMENTS

For oil vapors standing highest heat:

(a) Paste of sodium silicate and asbestos.

For gaskets for super-heated steam retorts, furnaces, etc.:

(b) Sodium silicate and glass.

(c) Sodium silicate, 50 parts; asbestos, 15 parts; slaked lime, 10 parts.

A metal cement:

(d) Sodium silicate, 1 part; oxides of zinc, lead, or iron, singly or mixed, 1 part.

(e) Zinc oxide, 2 parts; zinc chloride, 1 part; water to make a paste.

(f) Magnesium oxide, 2 parts; magnesium chloride, 1 part; water to make a paste.

(11) FLOUR AND STARCH

(a) Flaxseed makes a very tough cement but does not withstand water.

(b) Flour and molasses to a stiff paste.

A permanent cement for ordinary temperatures impervious but attacked by condensing steam and nitric vapors.

(c) Stiff flour paste and concentrated zinc chloride solution.

As a core compound:

(d) Dextrine and fine sand.

(12) MISCELLANEOUS

For insertion of glass tubes in brass or iron:

(a) Litharge and glycerine mixed to a stiff paste.

For high heat:

(b) Alumina, 1 part; sand, 4 parts; slaked lime, 1 part; borax, ½ part, water.

Core compounds:

(a) Dextrine, 1 part; sand, 10 parts; water to form a thick paste.

(b) Anthracite coal powdered with molasses added to thick paste.

(c) Rosin, partly saponified by soda lye, 1 part; flour, 2 parts; sand, 4 parts; with water as a diluent.

(d) Powdered glue, 1 part; flour, 4 parts; sand, 6 parts, water.

As a coating for glass ware to protect from injury by direct flame:

(a) A mixture of fire clay and plumbago made into a paste with water.

For retorts:

(a) Fine flour and lime, 1 part; potters earth ½ part; make a moist paste with white of egg well beaten with a little water.

For melting pots:

(b) Sift brick dust and mix with equal quantity of red lead; rub together with boiled linseed oil, which has been mixed with sand to a stiffness of cement. In covering dishes apply the paste first then apply sand and heat.

(c) Put freshly slaked lime with concentrated solution of borax, apply with a stiff brush and allow to dry. Upon heating a fused glaze is obtained.

For large pots:

(d) Litharge, 6 parts; fresh burnt lime, 4 parts; white bole, 2 parts; and mix with cold linseed oil.

Laurel Hill Laboratory,
General Chemical Co.

Suggested College Course on the Human Side of Engineering.—In our issue of Feb. 1 (page 123) we referred editorially to the splendid work carried out during the past nine or ten years by the International Committee of Young Men's Christian Associations (Industrial Department). They have now enlisted 4500 college men from 250 colleges who are reaching each week 100,000 working men and boys in voluntary service, teaching English to foreigners, instruction classes of American workmen, etc. A further outcome of this work is a suggested college course on the human side of engineering which has been prepared with the help of leading professors, business men and social workers. It is arranged to cover 64 or preferably 96 class periods—four or eight months' work at the rate of two or three periods a week. There are twelve sections: the human factor in industry; the evolution of the individual worker in industry; industrial organization and the influence of the modern system on the worker; human factors in production (capital and labor, immigration, unionism, etc.; working, living and leisure conditions); the ethics of engineering and business; vocational guidance and the education of employees; coöperative organizations; legislation and public opinion on industrial questions; the progress of typical companies; intelligent dealing with employees; the engineer's responsibility for service. A copy of a full outline of this suggested human engineering course will be sent on request by Mr. Fred. H. Rindge, Jr., secretary, Industrial Service Movement, 124 East Twenty-eighth Street, New York City.

Annual Meeting of Institute of Metals.—The Institute of Metals (London) will hold its annual meeting in the rooms of the Chemical Society on Wednesday, March 21 and 22. A special feature of the meeting will be a general discussion on metal melting, which includes six papers on melting of non-ferrous metals by gas, coke, oil fuel, and electricity, and under various pressures. The following papers will be presented:

AT THE MEETING ON MARCH 21:

"The General Properties of Stampings and Chill Castings in Brass of Approximately 60/40 Composition." By Owen W. Ellis, B.Sc. (London).

"Machining Properties of Brass." By Owen W. Ellis, B.Sc. (London).

"Surface Tension and Cohesion in Metals and Alloys." By Sydney W. Smith, B.Sc., A.R.S.M. (London).

"Aluminum Production by Electrolysis: A Note on the Mechanism of the Reaction." By R. Seligman, Ph. Nat.D. (London).

"Annealing of Nickel Silver" (Part II). By F. C. Thompson, D.Met., B.Sc. (Sheffield) (subject to being completed in time).

AT THE MEETING ON MARCH 22 (GENERAL DISCUSSION ON METAL MELTING):

"Metal Melting as Practised at the Royal Mint." By W. J. Hocking (London).

"Coal Gas as a Fuel for the Melting of Non-ferrous Alloys." By G. B. Brook (Sheffield).

"High Pressure Gas Melting." By C. M. Walter, M.Sc. (Birmingham).

"Contribution to Metal Melting Discussion." By H. M. Thornton (London) and H. Hartley, M.Sc. (London).

"An Electric Resistance Furnace for Melting in Crucibles." By H. C. Greenwood, D.Sc. (London), and R. S. Hutton, D.Sc. (Sheffield).

"Ideals and Limitations in the Melting of Non-ferrous Metals." By Carl Hering (Pa., U.S.A.).

"Metal Melting in a Simple Crude Oil Furnace." By H. S. Primrose (Ipswich).

Hydroelectric Power and Electrochemistry and Electrometallurgy in France—II

By C. O. Mailloux, E.E., D.Sc.

Member of the American Industrial Commission to France

It is in connection with the electrochemical and electrometallurgical industries that the importance of low cost of electrical energy is fully realized. It is soon discovered here that the figures mentioned in the first article as being exceptionally low for the cost of electric current for operating motors to produce mechanical power in cities like Lyon and St. Etienne would not only be high, but would be quite prohibitive in the case of the electric power required for the operation of electric furnaces or for the operation of most electrometallurgical and electrochemical processes, especially those which require the production of heat by electrical means.

In the case of the electrical energy required for electrochemical and electrometallurgical purposes, it is necessary, in order to arrive at the most satisfactory solution—the one giving the lowest cost—to consider separately the cost of producing power at the power station and the cost of transmitting it to distant points, and of distributing it at those points. The cost of transmitting and distributing power is often much higher than the cost of generating it. An outlay of capital is required to set up transmission lines, substations, transformers, distribution systems, etc. This means overhead charges for interest, taxes, etc., and maintenance charges for attendance, repairs, supplies, etc. Moreover, a certain loss of energy is inevitable in the transmission and distribution system. It must be remembered that the power "lost" between the power station and the point at which the useful power is delivered is just as much a part of the total power generated as the "useful" power itself. It is the "useful" power, however, that must cover the cost of both kinds of power. Hence, the greater the percentage of power that is lost in transmission lines and distribution systems the greater the cost of the "useful" power becomes. This makes it obvious that for very cheap power the losses between the point where it is generated and the point where it is utilized must be reduced to a minimum.

The capital outlay, the overhead charges, the loss of energy can all be avoided by utilizing the electric current at the point where it is generated. As a general rule, the nearer the location of the works to the power plant the lower the cost of power will be. Frequently there is an incidental advantage in locating the works near the power plant, namely, that the ground, the buildings and the facilities required for the works cost less. To offset these advantages there may be objections or disadvantages incidental to the location of the works near the power station, the principal one being difficulty and cost of transportation to the works of the raw material and supplies necessary for the product to be made, and also the cost and delay of transportation of the product itself from the works to the market.

In some cases there is every advantage and no disadvantage in locating the works near the power station. In other cases, for various reasons, the works may have to be located at some distance from the power station. The important point to be noted is that there is always a limit to that distance; there is a distance beyond which the power in question is not desirable for the purpose in view, for the very reason that the cost of the power delivered at the point of consumption becomes too high. The point of prohibitive cost differs according to the purpose and the process for which electrical energy is needed. In the case of metallurgical or chemical processes involving the use of electric furnaces or depending upon the heating effects produced by electric currents, the cost of electric current ought to be brought down to about $12 per electrical horsepower per year (which is equivalent to about $16 per kilowatt-year), and it is highly desirable that the cost should be as much below that figure as possible.

It is said that in the case of some of the large water powers in Norway, where the cost of development per horsepower was very low, the cost of power at the power station is as low as $5 or $6 per horsepower-year. These are exceptionally favorable cases. A power cost of $10 to $12 per horsepower-year would be considered low; above that price it becomes less satisfactory, and it may be too high for many purposes. The price charged at Niagara Falls, $15 per horsepower-year (equivalent to $20 per kilowatt-year), is considered high for many electrochemical and electrometallurgical purposes. Some of the power consumers there have found that it paid them to provide steam power for a part of their load to take care of their own "peaks" in power consumption, and thus maintain the Niagara power used by them as constant as possible. The reason is that the charge made for Niagara power increases with a decrease in the evenness of the load, as measured by what is termed the "load factor." It is significant that in these cases the consumer finds Niagara power too expensive for the whole of his requirements. This was not the case when the "base prices" for Niagara power were lower.

A cost of $16 per kilowatt-year (8760 hours) corresponds to very nearly one-fifth of a cent per kilowatt-hour. This justifies the statement previously made that a cost of 1 cent per kilowatt-hour would be prohibitively high for electrochemical work.

To obtain the low electrical power costs which are so desirable for electrochemical purposes, the cost of developing the water power must be very low per horsepower developed. This condition is usually favored by power sites of high head, in favorable locations permitting development with dams of small size and of low cost. It is often said that the concerns engaging in electrochemical and electrometallurgical operations requiring large amounts of electrical energy cannot afford to buy, but must themselves produce their electric current supply. The reason for this statement is that the cost of current supply obtained from a company that makes a business of furnishing electric power must include a fair profit for that company, whereas when the power is produced by the concern which needs it the profit is obtained from the product manufactured, and not from the power, which is generally reckoned at the cost of its production. It is for this reason that, with few, if any, exceptions, in the "white coal" region, the water powers supplying electrical energy to electrochemical and electrometallurgical companies belong to those companies, and were developed by them for their own purposes.

If electric power must be very cheap in order to be useful for electrochemical and electrometallurgical purposes, then the fact that so much power is used for these purposes in the "white coal" region of France may be regarded as fairly conclusive evidence of the low cost of production of that power. From the official figures which have already been given for the different uses made of the water power in the "white coal" region, it is seen that the power used in electrometallurgical works (225,000 hp.) and that used in electrochemical works (147,00 hp.) together make up 402,000 hp., or 54.5 per cent of the total power in that region. It may be fairly presumed from the physical characteristics of the white coal region that the undeveloped power in that region will not prove more expensive than that which is already

in use. Indeed, as the result of the extensive experience gained in connection with the construction and operation of the existing hydroelectric power plants, it may reasonably be expected that the cost of development and of operation, and, consequently, the cost of the "useful" power, from new power developments, can be further reduced. Moreover, the possibilities of cheap power in the region of the Pyrenees are also very good. It is quite conceivable, therefore, that there may be available in France an amount of very cheap hydroelectric power suitable and economical for electrochemical and electrometallurgical work that would, in time, bring the aggregate of such work to a point requiring as much as 1,500,000 or even 2,000,000 hp. When that time arrives, France will be occupying a position of highest importance in these industries. It certainly seems to have important odds in its favor in the race for leadership in this field. The good showing already made in the space of a few years by these industries, as shown by the very large total amount of power used for their kind of work, is a good sign that the great possibilities of these industries in France are understood and appreciated there, and that further important developments may be looked for in rapid succession.

Electrochemistry

The American Industrial Commission to France saw a large number of electrochemical and electrometallurgical plants, and it visited a few of them in the "white coal" region. One of these establishments belonged to the Société d'Electrochimie, which operates six plants, located at different places in France. At the establishment visited, which is near Riouperoux (Isère), the power utilized was about 6000 hp. The products made there included the rarer metals, aluminium, magnesium, sodium, calcium, all produced as pure metals, and sodium peroxide, calcium hydride, compressed oxygen, and various other chemical substances produced as chemical products.

This company was originally formed (in 1889) with the object of manufacturing chlorates of potassium and sodium by electrolysis. It played an important part in the pioneer days of the electrochemical industry in France. Besides developing the chlorate industry, it introduced in France the manufacture of metallic sodium and of sodium peroxide, the latter being a substance of great utility for bleaching vegetable fibrous materials, such as flax, cotton, ramie, etc.; it also introduced the manufacture of metallic calcium and of calcium hydride, the substance used for generating hydrogen gas in large quantities for inflating balloons. (One kilogram of this substance, when placed in water, will decompose enough water to set free over 1 cubic meter of hydrogen gas.)

The company also manufactures at some of its other works cyanide of potassium and of sodium, and various other chemicals used in the arts.

The applications which have been made of electrochemical processes in France include the production of a great variety of substances which may be classed into four groups:

Group 1—Calcium carbide.

Group 2—Nitrogen products, including nitrates, nitric acid, nitride of aluminium, and cyanamid of calcium.

Group 3—Chlorine and its compounds—the hypochlorites, chlorides and chlorates.

Group 4—Miscellaneous products; sodium, potassium, calcium, magnesium, and other rare metals; hydrogen and oxygen; carborundun; secondary products, etc.

Calcium Carbide.—It is well known that the calcium-carbide industry proved a serious disappointment many years ago. The demand for that material did not grow as fast as was anticipated, and in consequence a condition of overproduction was reached all over the world, which forced many concerns to devote attention to other specialties and to find other work for a part or the whole of their plants.

In 1910, while the aggregate production capacity of seventy plants located in nine European countries, also in Canada and in the United States, was over 360,000 tons per annum, the total demand and production fell under 250,000 tons. In that year there were about twenty electrochemical plants which produced calcium carbide in France, the total quantity made being 30,000 tons. In 1913 there were in France sixteen plants which produced calcium carbide, the total quantity made being 45,000 tons, out of an aggregate production for the entire world of 339,000 tons (see Table V). This increase in consumption was not due so much to increasing use of acetylene gas as an illuminant; it was due, mainly, to two other causes: first, the development of the flame method of cutting and welding metals, sometimes referred to as the "acetylene-gas method" of autogenous welding; second, the increase in production of "cyanamid," a substance which is made from calcium carbide. The consumption from these directions is likely to increase.

Nitrogenous Products.—Electric current is used for making these products in two ways: first, by processes of "direct fixation" of nitrogen from the air; second, by processes of "indirect fixation," which involve the prior production of substances that are chemically adapted and can be made suitable for absorbing nitrogen. The first method, which depends upon the effect of electric arc discharges through atmospheric air in inclosed spaces leads to the direct production of nitric acid, from which nitrates may afterward be prepared. It is interesting to note here that this method was first put in operation some fifteen or sixteen years ago at Niagara Falls by an American electrochemist, Mr. C. S. Bradley.

The second method arrives at the fixation of nitrogen in a more roundabout manner and by distinct steps. The first step is the preparation of a substance capable of absorbing nitrogen; the second step is the transformation of this substance into a nitrogenous compound; the third step is the production from that compound of nitrogenous products of the kinds desired. The best known example of the second method is the so-called cyanamid process. In this case the first step is the production of calcium carbide in the electric furnace. The second step is the transformation of calcium carbide into calcium cyanamide by heating powdered calcium carbide to a red heat, obtained from electric power, and then passing nitrogen through the mass, whereupon the following chemical reaction takes place:

$$CaC_2 + 2N = CaCN_2 + C$$

(i.e., calcium carbide + nitrogen = calcium cyanamid + free carbon).

The third step consists in obtaining ammonia, a nitrogenous substance, from the cyanamid of calcium by a very simple process, which depends on the fact that when brought in contact with steam, calcium cyanamid decomposes into carbonate of lime and ammonia in the manner indicated by the following chemical equation:

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$$

(i.e., calcium cyanamid + water = lime carbonate + ammonia).

This chemical property accounts for the action of cyanamid as a fertilizer. When placed in the ground the moisture of the soil causes ammonia to be set free, as in ordinary ammoniacal fertilizers.

The fourth step consists in making nitric acid and nitrates from the ammonia obtained by the process just mentioned.

The enormous field available for the production of artificial nitrates is shown by the fact that the consumption of natural mineral nitrates, which, as is well known, come practically altogether from the enormous nitrate beds in Peru and Chile, exceeds 2,000,000 tons per year in times of peace.

The largest plants for producing nitric acid and nitrates by direct fixation are located in Norway. The Norwegian Nitrogen Company began operations at Notodden, Norway, in 1905. In 1907 the success of this company led to the formation of a new company, with the object of increasing greatly the output, by developing and utilizing additional water power. The power developed up to the present time exceeds 350,000 hp., and it will eventually attain 500,000 hp. The output capacity, at present over 200,000 tons of nitrate per annum, will, in time, attain or exceed 300,000 tons. Even this large output, however, is small in comparison with the aggregate world consumption for times of peace just mentioned, which is enormously increased in times of war, because no explosive can be manufactured without nitric acid.

The synthetic or artificial nitrates have a fertilizing action which is substantially equal to that of the natural (Chilean) nitrate. They are, however, more hygroscopic and deliquescent, and therefore a package of artificial nitrate, when once opened, will not "keep" as well as the natural nitrate, and must be used up more promptly. This peculiarity has proved a handicap to the artificial nitrate as a substitute for the natural nitrate by creating the suspicion that it was chemically inferior to it. The fear of slow development in the consumption of and demand for the artificial nitrate has reacted upon, if not halted, its production to some extent in France. This condition of uncertainty as to the market for synthetic nitrates, coupled with the fact that such a large quantity of these nitrates was being produced in Norway, led the French electrochemical interests to show a preference for the manufacture of nitric acid rather than nitrates, and to select the methods and arrange the processes accordingly.

A French company, known as the "Nitrogen Company," has been operating, since 1909, a direct-fixation nitrogen plant near Briançon, with nine double furnaces, each of 450 to 600-kw. capacity, oxidizing nitrogen from the air and producing a product which is then transformed into nitric acid of 36 deg. The power capacity of the plant is to be increased from 8000 to 20,000 hp., with a corresponding increase in the output of nitric acid. Negotiations were made, some years ago, with the owners of the process for the establishment of similar plants in other portions of France, notably in the Pyrenees. The war may have interfered with the carrying out of such projects.

The great objection to all direct-fixation processes thus far developed is the comparatively large amount of electrical energy required per unit of product obtained. For this reason attention has of late been given to other processes, including the cyanamid process of producing nitrogenous substances.

In 1910 a company known as the General Nitride Company was formed in France with the object of exploiting the Serpek process for the manufacture of an ammoniacal fertilizer, known as aluminium nitride. The process is based upon the use of the electric furnace to heat crude alumina in an atmosphere of nitrogen, by which nitride of aluminium is produced. By another step of the process this substance is subsequently decomposed into ammonia and pure alumina, which is the raw material required for making aluminium. In this process the manufacture of a nitrogenous fertilizer thus becomes closely related to the manufacture of aluminium. The Serpek process, however, has not proved satisfactory, and from present indications, according to the investigations made by the National Research Council in this country in the last few months, it is not held in high favor, and is not considered likely to supersede either the "direct" fixation method or the other "indirect" methods, such as the calcium cyanamide method.

The total world production capacity of calcium cyanamide before the war did not exceed 100,000 tons per annum, of which France and the United States each produced about one-fifth. The production capacity has probably been increased considerably in the last two years.

Chlorine and Its Compounds.—Electrochemistry has furnished the simplest and cheapest methods for making chlorine and many of its compounds. It has stimulated the development of numerous industrial processes in which these chemical products find useful practical applications. There is a large and increasing demand for chlorinated products, which has manifested itself in a material increase in the amount of electric power utilized in this particular field of electrochemistry, in France as well as in America.

The electrolytic method of producing chlorine is theoretically quite simple; it consists merely in passing a continuous electrical current through a solution of sodium chloride (common salt), by which that substance is decomposed into its two constituent elements, namely, chlorine and sodium. The former is liberated at the positive pole, or anode, and escapes as a gas; the latter is liberated at the negative pole, or cathode, where it immediately decomposes the water that held the salt in solution to form caustic soda, which remains in solution, while the hydrogen thereby set free from the water is released and escapes into the atmosphere. In the practical application of this theoretically simple process there are various chemical and mechanical difficulties, resulting from the corrosive action of the chlorine produced, and the necessity of providing adequate means for its collection, and also of preventing its recombination with the soda that is also produced by the same electrolytic action. These difficulties have been overcome in various ways, and there are now numerous processes, some of them covered by patents, which have come into industrial use in many countries. A large industry has developed, which has affected the alkali industry in a radical and almost revolutionary manner, as will be pointed out later.

The chlorine produced by the electrolytic process is used as a source of supply of that substance in making hydrochloric acid and commercial chloride of lime, better known as "bleaching powder," and it has also become available as an article of commerce in liquid form at much lower cost than was formerly possible, with the consequence that a considerable demand for liquid chlorine has been developed. The abundance and cheapness of liquid chlorine have led to its use in making chlorides of various other metals and bases, such as chloride of ammonia, potassium, etc. Uses have been developed for many of these new chlorides, which were not utilized before because they were not obtainable in sufficient quantity.

Two important classes of chlorine compounds are obtainable by electrolysis, namely, hypochlorites and chlorates. The hypochlorites of sodium, potassium and magnesium are those best known and most frequently made. These compounds share in common certain very valuable chemical properties, which render them very useful, in form of "bleach liquors," for bleaching purposes, and more especially in the form of disinfectants for purifying contaminated and polluted waters. Hypochlorite of soda is prepared in greater quantity than the other hypochlorites, because the material from which it

is prepared (common salt) is more abundant and cheaper than the material required for the other hypochlorites.

The chlorates of potassium and sodium constitute one of the most important classes of compounds of chlorine, on account of the great demand for them in the arts. They are used in making matches, explosives, detonators, in dyeing, and for various other important purposes.

The production of chlorates was one of the early developments of electrochemistry in France. The first plant for making chlorates by electrolysis was established in France as early as 1886. Since that time three other plants have been established. Before the war France exported a considerable quantity (about 4000 tons per year) of chlorates.

Another chlorine compound which has been obtained by electrolysis is perchlorate of ammonium, a chemical product which is very stable and not readily exploded, but which, nevertheless, when mixed with organic bodies, produces explosives of great power, comparable with dynamite and chlorate explosives.

Another chlorine compound, carbon tetrachloride, is obtained as a by-product in some processes for making chlorine and caustic soda. Various other compounds of chlorine with carbon and with hydrogen, possessing remarkable chemical properties and susceptible of important industrial applications, such as the di-, tri-, tetra- and per-chlorides of ethylene, have come into existence and promise to be valuable by-products of the manufacture of chlorine, the chlorides and chlorates.

Miscellaneous Electrochemical Products.—The production of caustic soda, already mentioned as a circumstance attending the production of chlorine gas, when a solution of common salt is electrolyzed, is really an electrochemical achievement of greater importance and interest than the production of chlorine itself, because of its possible far-reaching effects on one of the oldest and most important chemical industries, that of "alkali manufacture." It happens that the electrolytic production of caustic soda comes into competition with the older methods of manufacturing that substance.

Electrolytic Soda and the Alkali Industry.—The alkali industry had its origin in France, as a real "war baby," in the beginning and early part of the last century. Even before the French Revolution the scarcity of alkali and the increasing demand for it in France had led to the search for methods of artificial "soda ash" and soda production. The need of such methods was made more urgent by the wars waged against France under the first republic, and those waged against or by France under Napoleon, because the supply of alkali previously derived from the other countries was then practically cut off altogether. It was necessity that prompted the many attempts made in France during that period to manufacture soda artificially from common salt.

Of the various methods proposed and tried, one—invented by a French chemist, Nicolas Leblanc—proved to be a satisfactory solution of the problem, and to be capable of giving useful industrial results, and in a remarkably short time it had, while conferring a great boon on France, revolutionized completely the world's production of soda. The Leblanc soda process was rapidly taken up in other countries, especially in England, where its development soon created the new and important industry of alkali manufacture, in which England rapidly took the foremost position, which it held practically undisputed until the beginning of this century.

In the last quarter of the nineteenth century, a new and better process, known as the "ammonia-soda" process, came into use, of which the best known example is the well-known "Solvay" process, developed by Ernest Solvay, the Belgian chemist. The use of this process extended rapidly, until it served for producing the greater part of all the soda ash of commerce. England is now the only country where the Leblanc process is still in use to some extent.

It is practically against the Solvay process, therefore, that the electrolytic process for producing both chlorine and caustic soda must compete. This competition is of great interest to the electrochemical industry, not only in France, but also in America, where there are many electrolytic chlorine-and-soda plants. The Solvay process is also firmly established in both of these countries. The broad question is, to what extent the Solvay and Leblanc processes are likely to lose the ground now held by them as the principal source of production of the world's supply. The answer to this question depends upon the demand for chlorine and its compounds.

The Leblanc process was devised as a source of soda, and not as a source of chlorine. Indeed, the chlorine, which is set free, in the first stage of the process, as hydrochloric acid, in gaseous, anhydrous form, was at first allowed to escape in the air, and it was only when its corrosive action upon buildings, vegetation, etc., became intolerable that steps were taken to recover it and to utilize it. (In England the free liberation of this gas into the air was made the subject of anti-nuisance legislation.) The necessity of avoiding a nuisance was a blessing in disguise, for the development of methods for saving this gas, by condensation and otherwise, made the Leblanc process the principal source of supply of hydrochloric acid and of bleaching powder (chloride of lime).

While with the Leblanc process the operation of obtaining hydrochloric acid is relatively simple and cheap, the operation of obtaining pure chlorine gas, which necessitates the oxidation of the hydrogen contained in hydrochloric acid, is complicated and costly.

The ammonia-soda process is still less suitable than the Leblanc process as a source of chlorine.

The electrolytic chlorine-and-soda process is the only process that produces pure chlorine gas directly. Unfortunately, it cannot afford to throw the chlorine away, as the Leblanc process did, and still does to some extent, but must find a market for it in order to compete with the ammonia-soda process. That is why the future of the electrolytic process hinges upon the demand for chlorine. The difficulty is that the market for the alkali (soda) portion of the output is at present many times (possibly eight or more times) greater than the market for chlorine and its compounds.

The use of chlorine in the "chlorination" process of treating ores is an example of a relatively new use for liquid chlorine which may add materially to the demand for that substance. The increase in demand for hydrochloric acid will also benefit principally the electrolytic process, because the Leblanc process, now the principal source of that product, is on the wane, and may be discontinued altogether in due time. It is reasonable to expect, therefore, that the electrolytic process will get a constantly increasing share of the soda market; but it now seems hard to conceive of its being able to attain, let alone surpass, the ammonia-soda process as a purveyor of the world's demands for alkali.

Oxygen and Hydrogen.—The production of these two substances by electrolysis has been carried on in France since 1897. There are two plants in operation producing together about 300 cubic meters of oxygen and 600 cubic meters of hydrogen per day. There is an increasing demand for these gases for a variety of uses. The electrolytic process does not promise, however, to be able to compete successfully, so far as oxygen is con-

cerned, with the process of fractional distillation of liquid air, and it does not seem that there is much future for the electrolytic process.

The Société d'Electrochimie manufactures a product called "oxylithe" and another called "hydrolithe," which when put in water liberate oxygen in one case and hydrogen in the other case. A kilogram of oxylithe can generate 140 liters of oxygen and a kilogram of hydrolithe can generate 1000 liters of hydrogen. The commission witnessed experiments with these materials, but it did not obtain information as to their exact nature or their preparation.

Minor Products.—Small quantities are made by electrochemical means of various chemical products, including the following: Sodium-chromate, potassium-ferrocyanide, lead carbonate (white lead), minerals for colors (such as cadmium yellow and Paris blue), aniline colors, chloroform, iodoform, reduction products of mono-nitrobenzine, silicides of calcium, sodium, and potassium, baryta-salts, phosphorus, ozone.

Electrometallurgy

The figures given elsewhere for the total hydraulic power capacity installed in the region of the Alps show that almost 35 per cent of the aggregate power is utilized in electrometallurgical work. The only industry utilizing more hydroelectric power is that of "lighting and power," which utilizes 39.4 per cent of the whole amount.

In electrometallurgy—which is the art of producing and treating metals, metalloids and alloys by the aid of electricity—all processes carried out, and all chemical, physical and metallurgical effects produced, depend upon the action of energy on matter in one or both of two ways: first, by electrothermal action, i.e., the development of heat, usually, but not necessarily, intense, in the materials to be operated upon; second, by electrolytic action, i.e., a selective bodily transfer, in both directions, along the path of the electric current of certain chemical elements, so as to cause them either to accumulate and be deposited or else to be set free from the mass at the points thereof constituting the inlet and the outlet for the electric current.

While a continuous electric current can produce both kinds of action, the alternating current can only produce electrothermal action.

The processes of electrometallurgy are carried out in containers of two sorts: electric furnaces or ovens, and electrolytic cells or vats. The two kinds of actions (thermic and electrolytic) may occur in both sorts of containers, either independently or conjointly, according to circumstances and conditions.

Electric Furnace.—The principle of the electric furnace was discovered in 1809 by Sir Humphry Davy, who, using an electric arc in a crucible, obtained thermic and electrolytic actions by which he was able to produce for the first time many rare metals. In 1853 the first attempts were made in France and in England to construct electric furnaces for smelting ores. In 1878 Sir William Siemens, in England, patented a form of electric furnace, embodying many features of the modern electric furnace. In 1886, in France, Héroult put in operation the first electric furnace used for electrometallurgical work on a commercial scale. It was used at first for making aluminium. Later he developed a furnace for making steel. Both furnaces have given satisfactory results and are used in France and in America. Furnaces of various other types have been devised in many countries by many inventors. The principal types are the arc furnace, with alternating current; the "induction" single-phase furnace; the "induction" three-phase furnace, and various forms of "resistance" furnace. Each type is supposed to have its advantages, and it may also have its disadvantages. From the electrothermal standpoint the claims made for any type may also be claimed for the others. These may be summarized as follows:

1. Ability to attain and maintain much higher temperatures than are possible in non-electric furnaces; instead of being limited to about 1800 deg. C. as in coke or gas furnaces, the temperature of an electric furnace may attain 3000 deg. C., or even 3500 deg. C.; in fact, the only limit is the melting temperature of the refractory linings of the furnace itself.

2. The heat is produced more efficiently and applied more effectually, because the work is done in a smaller space, the mass operated on is more compact, the working temperatures are higher, and the heat losses are smaller.

3. By reason of the higher temperatures, the melting and mingling of the various constituents of the charge and the fluidity of the mass are more perfect, and the chemical reactions sought to be obtained are produced more completely and effectively.

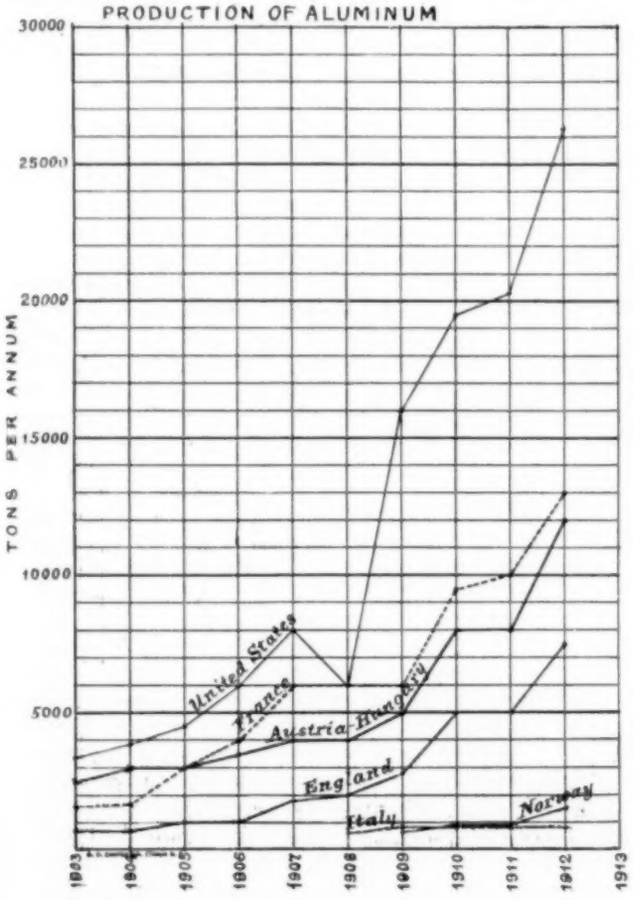
4. The atmosphere inside the furnace can be controlled much more perfectly than in a coke or gas furnace, because the absence of fuel does away with the presence of gases, and the necessity of air, and the temperature can be made chemically neutral or it can be made chemically reactive in any way desired by the introduction of any gas or vapor.

5. The composition and the proportions of the materials put into the furnace can be varied at will; there is no restriction or requirement imposed by fuel, affecting the amount or quality of any material used for the charge; additions for varying the character and composition of the charge can be readily made at any stage, and products of varied kind and quality can be obtained with ease and precision.

Aluminium.—It was this metal which gave France an opening for entering the field of electrometallurgy. It had, it may be said, pre-empted the field of aluminium production at an early date; indeed, it was the first country in the world to produce aluminium commercially. Until 1850 only small quantities of aluminium had been prepared by a very imperfect and expensive process. The market price of this metal was then over 1000 francs per kilogram. At a chemical plant in the south of France, where the Leblanc soda process was in operation, the production of aluminium was begun in 1861 by a chemical process devised some time before (in 1851) by Sainte-Claire-Deville, and which had been developed by him, between 1854 and 1859, to a point that enabled the selling price of aluminium to be reduced to about 300 francs per kilogram, and the production by that process was continued for twenty-eight years (until 1889), when it was replaced by an electric furnace process, which is still in operation, so that this concern enjoys the distinction of being the pioneer in aluminum production. It is now one of the largest producers of aluminium in France. (See Table III.)

The aluminium industry is of special interest and importance both to France and the United States. The two countries share honors for the inventions to which the development of the modern method of aluminium production is due, the names of Héroult and Minet in France and of Hall, the Cowles brothers and Bradley in the United States being those of the pioneers who blazed the path to industrial success, and these two countries are also those having the largest production capacity. Héroult's name deservedly takes precedence over all others in the history of the production of aluminium by electrolysis. His French patent of April 23, 1886, contains the first complete, definite, description of

the process which proved to be (and remained) the most practical and successful one, namely, the process depending upon the electrolysis of alumina dissolved in a bath of fused cryolite; and there is no doubt that he was the first to reduce the invention to practice and to produce aluminium industrially by that process, which is still in general use with modifications and improvements in details which are of relatively minor importance. The following table gives an idea of the relative production capacities of different countries two or three years before the war:



ALUMINIUM PRODUCTION IN DIFFERENT COUNTRIES

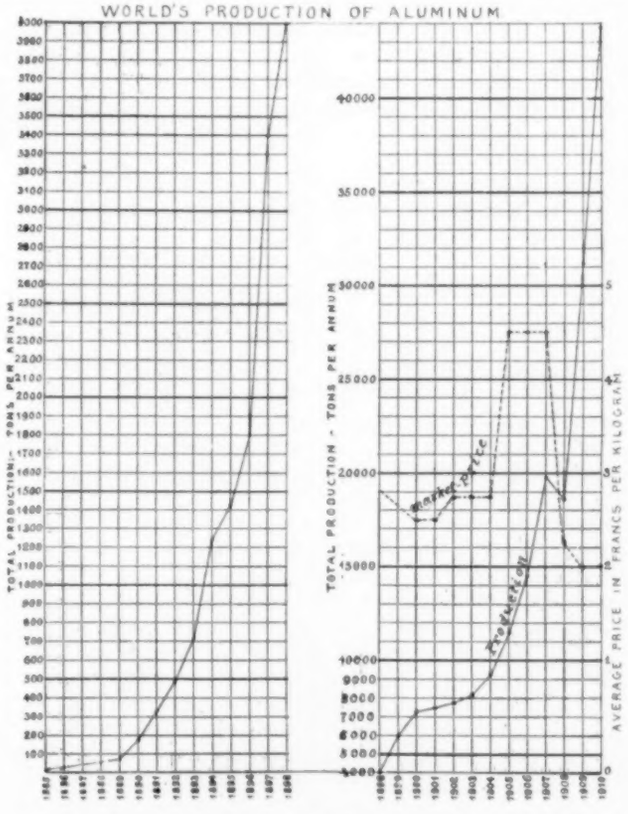
The table shows that France led the world, with a production capacity equal to 39.4 per cent of the total. Of the ten French aluminium plants, the nine which are located in the region of the Alps represent an aggregate of 120,000 hp.; the other is located in southern France. It is interesting to note that from 1886 to 1896 it was Switzerland and not France that led the world in production capacity of aluminium. Its production capacity, after that time, remained nearly stationary, while that of France continued to increase.

One important reason why France attained a leading position in aluminium production was the fact that, at first, and until recent years, practically all the "ore" used for making aluminium (namely, bauxite) came from France. The extensive beds of bauxite found in southern France are still the main source of supply of that material for all the aluminium plants in Europe. The discovery of large quantities of this material in the South in the United States has made this country practically independent of France in this respect. Statistics for 1910 show that out of a total world demand of 271,000 tons of bauxite, France supplied 128,000 tons and the United States 129,000, so that only 14,000 tons came from other countries. The French bauxite is generally considered superior in quality to that from any other source.

In spite of its great advantages in having cheap power, and also the best and cheapest supply of aluminium "ore," France has not retained the leading position which it had for a time, and which it hoped to retain indefinitely, in regard to total yearly production. With a domestic consumption of only about 3000 tons, and a production capacity of 19,000 tons per year, there is a large surplus capacity which must depend on finding a market by exportation. The hopes of France and of all European producers of aluminium to find a market in the United States for a considerable portion of their output were destroyed by our protective tariff.

PRODUCTION-CAPACITY FOR ALUMINIUM

Country	Number of Concerns	Number of Plants	Aggregate H. P.	Capacity in Tons per Year	Per Cent of Total
France	6	10	140,000	19,000	39.2
United States	3	3	105,000	12,500	25.8
Canada	1	1	20,000	2,500	5.2
Switzerland	1	2	27,000	6,000	12.4
Germany	1	1	5,000	600	1.2
Austria	1	1	5,000	800	1.6
England	2	2	21,000	3,800	7.8
Norway	2	2	21,000	2,100	4.3
Italy	2	2	4,000	1,200	2.5
Total	19	24	348,000	48,500	100.00



WORLD'S PRODUCTION OF ALUMINIUM SINCE 1885

The United States has become the country of greatest demand for and greatest production of aluminium. The war has further increased the demand and has stimulated the production to very high degrees. The American producers of aluminium are in control of the market at present, with good prospects of retaining that control.

The lack of sufficient market to keep the French aluminium plants fully occupied has necessitated the diversion of a considerable portion of their capacity to other electrometallurgical or electrochemical work, including making of carborundum, steel, ferro-alloys, etc.

Electrosiderurgy.—Even after the electric furnace had been in successful operation for a period of ten years or more in the production of aluminium on a large commercial scale, its application to the metallurgy of iron and steel was still regarded as of doubtful utility, and as having a rather limited field. There had been an enormous amount of laboratory and experimental work done, both in Europe and in America, in devising and trying out processes and methods of using the electric furnace for making steel, but the outcome of all these efforts had been very disappointing and discouraging. The metallurgist, who had to produce results industrially and commercially, and who was doing it with the methods already in use, could not very well be content with a new process, even though it was "electric," just because it would work; no matter how perfectly it worked, he insisted that it must pay, and, unfortunately, while it was, in most cases, easy enough to satisfy him that the electric furnace would "work," it was usually impossible to demonstrate to his satisfaction that it would "pay."

The aim and the hope, at first, were to make the electric furnace "work," and also to make it "pay," in the larger field of steel making, as a competitor or a substitute for the older methods of making low-priced steels, depending on the use of furnaces heated by coke or other fuel. It became apparent in time that while the electric furnace might be able to compete with the crucible in the productions of steels and ferro-alloys of higher grade and price, its hopes of success in competition with the open-hearth furnace must be indefinitely deferred. These prospects were foreshadowed quite clearly as early as 1904, in a comprehensive study published by the Canadian Government, which was entitled "*Report of the Commission appointed to investigate the different electrothermic processes for the smelting of iron ores and the making of steel, in operation in Europe.*" In the "general conclusions" formulated by the distinguished metallurgist and steel and iron expert attached to this commission, Mr. F. W. Harbord, of the Royal Engineering College, London, it was already possible to see the trend of the applications of the electric furnace and their limitations. It was stated, in these conclusions, that "steel equal in all respects to the best Sheffield crucible steel can be produced by electric furnace processes, at a cost considerably less than the cost of producing a high-class crucible steel"; also, that "structural steel to compete with Siemens or Bessemer steel could not be economically produced by the electric furnace, and that such furnaces could be used economically for the production of only very high class steel for special purposes." It was admitted that pig iron of any desired kind and quality could be readily produced; but it was pointed out that its production on a commercial scale at a price to compete with the blast furnace was possible only when electric energy is very cheap (not over $10 per horsepower year), and fuel very dear (at least $7 per ton). The further improvements made in recent years in blast furnace methods of producing pig iron, which led to further reductions in the cost of production by such methods, have increased still more the handicap against the electric furnace. The fact is that in the field of pig-iron production, the electric furnace instead of overtaking the blast furnace, has found itself falling more and more behind it, in point of cost, in recent years. At the present time the electric furnace could not compete with blast furnace in the production of pig iron, unless electric power cost much less than $10 per horsepower year, and coke much more than $7 per ton; so that the prospects are even more doubtful than before. It took considerable time, and many experiments, some of which were costly, to make it quite clear that the electric furnace had better prospects of industrial success in competing with the *crucible* than with the *blast furnace*. After this lesson had been learned—in other words, after it was realized that the electric furnace might find a place and field of usefulness somewhere between the crucible and the furnace—the efforts made to adapt the electric furnac to purposes for which it was better suited were made more intelligently, and they began to yield results, and it was not long before the electric furnace found a permanent place and a profitable field in the metallurgy of steel. It has shown itself capable of improving the quality of the product and reducing its cost in many cases, and in the last fifteen years a new branch of the steel industry, "electrosiderurgy," has been developed, which has attained considerable importance.

This new industry has made great progress in France, where the cheap hydroelectric power available in the "white coal" region is very favorable to its development. In 1914 there were twenty-five plants equipped with electric furnaces for making steel, and two such plants under construction, practically all of them in the "white coal" region (see Table IX). The aggregate charge capacity of the furnaces in these plants was over 135 tons, the largest furnaces being of 12 tons charge capacity. Of course, the war has caused an enormous increase in production capacity in all these plants, and in many other electrometallurgical plants in which electric furnaces were formerly used for the production of aluminium, calcium carbide, etc., the furnaces have been replaced or transformed so as to make steel.

The commission had the privilege of visiting one of the largest "electrosiderurgical" plants in France, namely, the works of the Compagnie des Forges et Aciéries Electriques Paul Girod, and the works of the Société Electro-Métallurgique Procédés Paul Girod, which are affiliated establishments, located together at Ugine, in Savoie (in the "white coal" region).

The first of these establishments is equipped for making electric steel castings up to 25 tons, and also with the necessary machinery for rolling, forging, turning and machining heavy steel pieces, for making ordnance, also war munitions and war material of various kinds. The most interesting and novel feature of this establishment to the commission was the electric steel furnace equipment, which serves for producing steel for making steel billets for the forges, and also for melting steel for making steel castings in the foundry. The furnaces and their operation were fully shown and explained to the commission. The operations incidental to the charging, the beginning and the end of the furnace "heats" and making of castings were seen by the commission. The furnaces used are of the Girod type, the invention of M. Paul Girod.

Girod Furnace.—This furnace is very ingenious in design and seems extremely well adapted to its purpose. It is a hearth furnace of a kind which can be tilted like a Bessemer converter. It suggests a huge covered iron ladle held in a tilting frame. Instead of being charged through the top, like a Bessemer converter, however, it is charged through an opening in one side, which is fitted with a sliding door, through which the slag is also removed. On the opposite side of the furnace is another opening—the taphole—for discharging the molten steel. The steel frame carrying the furnace can be tilted to one side for removing the slag through the charging door or to the other side for tapping the furnace and discharging it. The frame tilts on huge trunnions mounted on large roller bearings. The tilting is done by an electric motor or by a hydraulic plunger. The hearth of the furnace is square, with rounded corners, or it may be circular.

TABLE I—ELECTRIC STEEL PRODUCTION

	Tons		
	1911	1912	1913
France	13,850	15,848	20,757
Germany and Luxembourg	60,654	74,177	88,881
Austria	21,606	19,891	24,902
Hungary	1,261	1,665	1,935
United States	29,571	18,602	.....

The bottom and sides are lined with refractory material. As the steel made is "basic," the lining is of basic character. Two basic lining materials, "magnesite" and "dolomite," have been used. Dolomite has been found preferable, and is now used altogether; it contains about 50 per cent of lime and 35 per cent of magnesia, the remaining 15 per cent being mainly silica and iron. The lining endures about 120 heats in the small furnaces and 90 to 100 heats in the large furnaces. The side walls need more frequent repairs than the hearth, especially at the slag level, where they are most strongly attacked and wear out most rapidly, requiring partial repairs with dolomite between the heats. The bottom is not usually repaired until the side walls are repaired, and, as a rule, only an upper layer or crust of the bottom is removed down to a depth of 4 to 6 in., which is then replaced by a new layer of dolomite, which is tamped into a solid pavement. The roof of the furnace, which is arched, is lined with silica bricks, carefully fitted together into the iron "cover" of the furnace. This lining stands about seventy heats in the small furnace and about fifty heats in the large furnace. The total maintenance cost of the furnace lining is said to be about 30 cents per ton of steel. The electric current used in the furnace is conveyed to the furnace charge by large carbon electrodes suspended in a support frame above the furnace, and passing downward in a vertical line through the cover or roof of the furnace. The supporting frame holds up each carbon at a height such that its lower end is near the slag level, as is usual in electric steel furnaces. The electric circuit through the furnace is completed by the current passing through the charge to reach the furnace shell. There are several steel electrodes (water-cooled) protruding upward through the hearth lining which serve as collectors for the return current. These are located as far away as possible from the path of the carbon electrodes to compel the current to go through as large a mass of the charge as possible on its way from the carbon electrode to the steel electrodes. It is stated that the passage of the current produces electromagnetic rotation in the charge which stirs up the bath and hastens the chemical reactions produced in it. The carbon electrodes are gradually consumed in the furnace and have to be replaced periodically. The water-cooled steel electrodes last indefinitely.

TABLE II—PRODUCTION OF "FERRO-ALLOYS" IN FRANCE, INCLUDING FERRO-MANGANESE, FERROSILICON, FERROCHROMIUM, FERROTUNGSTEN, ETC.

Years	Tons Produced		Per Cent of Total	Total
	Coke Furnace	Electric Furnace		
190[illegible]	32,561	11,706	26	44,267
190[illegible]	39,194	13,657	26	52,851
190[illegible]	41,489	15,740	27	57,229
190[illegible]	46,693	15,329	24	62,022
190[illegible]	39,206	14,867	28	54,073
1910	40,106	24,353	36	64,459
191[illegible]	38,770	31,270	44	70,040
1912	46,372	30,660	40	77,032
1913	49,287	32,230	40	81,517

TABLE III—PRODUCTION OF CHEMICALS BY ELECTROTHERMIC PROCESSES

Countries	Tons Produced		
	Cyanamide	Calcium Carbide	Calcium Nitrate
France	7,000	1,000	.....
Austria-Hungary	10,000	2,000	.....
Italy	10,500	.....	.....
Switzerland	10,000	300	.....
Norway	40,000	.....	22,000
United States	24,000	5,000	.....
Germany	25,000	.....	.....

The Girod furnace can be operated by either continuous or alternating-electric current, because its operation depends on "electrothermal" action only, and does not utilize electrolytic action at all. The current used at Ugine is alternating current of low frequency (25 cycles). The source of supply is "three-phase." The smaller furnaces (of 2 to 3 tons capacity) are of single-phase type, being supplied with current drawn from one phase only of the electric current supply system. The large furnaces (of 10 to 12 tons capacity) are of three-phase type, and are supplied with current from all three phases of the supply system. The small furnaces have only one carbon electrode (for single-phase current). The large furnaces have four carbon electrodes, and when used with three-phase current, as is the case at Ugine, one of the three phases is connected with two carbon electrodes. The current per phase is about 8000 amp., and the voltage ranges from 60 to 75 volts, according to the charge. Usually the voltage is about 65 volts for the small furnaces and about 70 volts for the large furnaces. The amount of current passing through each electrode is controllable individually. This may be done by hand or it may be done automatically by an ingenious regulating apparatus. The current is usually controlled by hand regulation for a few moments at the time of turning it on the furnace when starting a heat; after that it is regulated by the automatic controller, which can be set for any desired amount of current.

The six furnaces that were in operation have an aggregate charge capacity of 33 tons. Two more furnaces were under construction, one of 2 tons, one of 12 tons, which will make the aggregate charge capacity 47 tons. Each furnace can be used for making at least three heats per day. Each heat requires about 6½ hours. With the six furnaces already in use there was no difficulty in making 3000 tons of electric steel per month, or an average of 100 tons per day.

The operation of this form of electric furnace is much like that of a basic open-hearth furnace. It can be used, like the open-hearth furnace, for making steel either by the Siemens ("pig-and-ore") process or else by the Siemens-Martin ("pig-and-scrap") process. These two processes, it is well known, differ in the manner in which the excess of carbon in the

TABLE IV—PRODUCTION OF ALUMINIUM

Countries	Tons Produced									
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
United States and Canada	3400	3900	4,500	6,000	8,000	6,000	16,000	29,500	20,300	26,300
Germany	....	....	.....	.....	.....	.....	.....	.....	.....	.....
Austria-Hungary	2500	3000	3,000	3,500	4,000	4,000	5,000	8,000	8,000	12,000
Switzerland	....	....	.....	.....	.....	.....	.....	.....	.....	.....
France	1600	1700	3,000	4,000	6,000	6,000	6,000	9,500	10,000	13,000
England	700	700	1,000	1,000	1,800	2,000	2,800	5,000	5,000	7,500
Italy	....	....	.....	.....	.....	600	800	800	800	800
Norway	....	....	.....	.....	.....	.....	600	900	900	1,500
	8200	9300	11,500	14,500	19,800	18,600	31,200	43,800	45,000	61,100

TABLE V—PRODUCTION OF CALCIUM CARBIDE BY THE ELECTRIC FURNACE IN 1913

Countries	No. of Plants	Tons			
		Produced	Consumed	Exported	Imported
France and colonies	16	45,000	45,000	.....	.....
Sweden and Norway	8	75,000	3,000	72,000	.....
Other European countries	42	130,000	164,800	51,000	85,800
Balkan countries	1	1,000	4,000	.....	3,000
United States	3	70,000	55,400	14,600	.....
Canada	3	12,000	6,000	6,000	.....
Latin America	1	.....	28,300	.....	28,300
Africa	...	.....	6,500	.....	6,500
Australia	...	.....	20,000	.....	20,000
Japan, China	3	6,000	6,000	.....	.....
Total	77	339,000	339,000	143,600	143,600

pig iron is removed in order to convert the pig iron into steel. The first process accomplishes the desired result by the oxidation of the carbon by the action of oxygen introduced in the furnace in the form of iron ores of the oxide variety, such as red or brown haematite or magnetite iron ores; the second process accomplishes the desired result by dilution of the carbon, by the addition to the furnace charge of sufficient quantities of scrap iron and steel, which contain carbon in much smaller proportion than pig iron or cast iron.

As with the open-hearth furnace, the charge may be melted down in the furnace itself, or it may be delivered into the furnace in the molten state. The latter is the preferable way, because the heat required for melting purposes can be obtained more cheaply in an open-hearth or a cupola furnace than by electrical means. The most practical way to use the electric furnace, in fact, is to restrict its use to processes and operations which cannot be done so well, if at all, or so cheaply, by any other means.

The process of making steel by the electric furnace comprises two phases or stages, the "oxidation" or "dephosphorization" stage and the "deoxidation-and-desulphurization" stage. In the oxidation stage the metallurgical reactions are substantially the same as in the open-hearth furnace; in the second or "deoxidation" stage they are somewhat different, owing, in a great measure, to the fact that the atmosphere in the electric furnace is entirely free from sulphur and almost entirely free from oxygen, whereas both of these reagents always exist in the open-hearth furnace, the former being due to the fuel and the latter to the air passing through the furnace. The absence of sulphur and oxygen in the atmosphere of the electric furnace is of no special advantage in the oxidation stage of steel making; it may perhaps be regarded as a disadvantage; but it is of the greatest advantage in the deoxidation stage of the process. The superior quality of the steel obtained by the electric furnace is, indeed, believed to be due in considerable measure to the neutral, non-oxidizing condition of the atmosphere of the electric furnace.

In the first or oxidation stage the presence of oxygen in the furnace atmosphere may be helpful, because the object sought is to oxidize the impurities, carbon, manganese, sulphur and especially phosphorus, as the first chemical step in their removal from the metal. In this stage an oxidizing slag which is highly *basic* is formed by the melting of iron oxide ore and lime, which are added to the charge from time to time, with, perhaps, a small quantity of silica. This slag, which floats above the molten metal, furnishes, from the iron oxide, the oxygen necessary for oxidizing the phosphorus to phosphoric acid, and it also furnishes, from the lime, the "base" necessary for combination with the phosphoric acid to form phosphate of lime, which remains in solution in the slag. The iron oxide also furnishes oxygen for oxidizing the carbon to carbonic oxide (which burns, producing carbonic dioxide, if there is oxygen in the furnace atmosphere), and also for oxidizing a part of the sulphur to sulphur-dioxide, which escapes. Phosphorus, which is the most objectionable impurity, is the easiest to remove completely. The oxidation of the carbon and manganese proceeds more slowly, in spite of the high temperature in the furnace. Practically all the phosphorus is removed during this stage of the refining process. The sulphur is only decreased by from 25 to 33 per cent.

At the end of the first stage the slag is removed and fresh lime is added to remove the last traces of phosphoric acid and prevent rephosphorization of the bath, by the additions of deoxidizing reagents (containing carbon, silicon, etc.), made to it in the second stage.

In the second stage the presence of oxygen in the furnace atmosphere is actually harmful, the object now being to remove, as completely as possible, the oxygen absorbed by the metal during the dephosphorization stage. The first step is to introduce a small quantity of deoxidizing reagents like carbon, ferrosilicon, etc. The molten metal is then covered with a very basic slag produced by the melting of lime, to which is added a small quantity of sand and fluorspar. The proportions used per ton of steel are the following: About 1 kilo (2.2 lb.) of ferrosilicon (containing 50 per cent of silicon), about 20 kilos (44 lb.) of lime, and 3 kilos each (6.6 lb.) of sand and fluorspar. The ferrous oxide formed on the unprotected surface of the metal at the end of the first stage, after the removal of the oxidizing slap, is dissolved by the deoxidizing slag, which turns black. It is necessary to secure the complete deoxidation not only of any iron oxide contained either in the metal or in the slag, but also of the lime in the slag. A certain excess of deoxidizing reagent is therefore desirable. This is provided by the addition of a small quantity of powdered petroleum coke (1 to 2 kilos., or 2 to 4 lb.) per ton of steel. The complete removal of the sulphur, which is so desirable in steel making, depends at this juncture upon the complete deoxidation of the lime in the slag, as this furnishes the reagent (calcium) necessary for the elimination of the sulphur present in the molten metal. We now see the great advantage of the electric furnace. The presence of oxygen in the furnace atmosphere would interfere with the reaction just mentioned, by causing the reoxidation of the calcium into lime. This is precisely what would happen in a Bessemer converter or in an open-hearth furnace; and it is for this reason that in these processes the sulphur cannot be removed by the deoxidation method just mentioned. The advantage of that method is shown by a comparison of the practical results. With the open-hearth process there is much difficulty in bringing the percentage of sulphur down to 0.03 per cent, and still more difficulty in reducing it to 0.02 per cent, whereas with the electric furnace it can readily be brought down to less than 0.01 per cent.

TABLE VI—EXPORTS OF FRENCH FERRO-ALLOYS

Exported to	Tons Exported									
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Germany	....	18	227	1715	2561	2282	2376	2878	2251	2948
Belgium	263	545	3069	3960	1889	3783	2143	1516	1816	1794
Great Britain	500	434	1150	1248	1914	1718	2521	3566	3189	4436
Switzerland	....	....	....	154	....	1160	578	1397	1672	1476
United States	66	....	....	....	450	....	....	980	256	235
Other countries	63	163	598	681	1335	633	1618	1905	2498	2218
Totals	892	1160	5044	7758	8149	9576	9236	12,242	11,682	12,307

TABLE VII—EXPORTS OF FRENCH ALUMINIUM

Exported to	Tons Exported									
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Germany	24	148	245	540	506	457	1479	1394	1684	1182
Belgium	.....	33	107	163	122	...	173	156	89	810
Great Britain	.....	.....	116	203	326	122	354	146	338	548
Italy	107	45	75	164	122	23	.....	.....	.....	.....
Russia	373	336	296	291	14	280	393	165	176	256
Switzerland	33	.....	.....	70	12	142	1519	1802	1293	1484
United States	.....	.....	.....	.....	.....	49	83	193	87	992
Other countries	125	101	86	43	16	259	524	292	393	1354
Total	662	663	925	1474	1118	1332	4525	4148	4060	6626

After the desulphurization has been carried to the point desired, the deoxidizing slag is removed, carrying the calcium-sulphide, which, while almost insoluble in the metal, is easily soluble in the slag. The finishing touches are given to the metal by adding whatever is necessary to give the metal the composition and properties desired; and the metal is then emptied out into ladles for use in making ingots or castings.

If desired, the whole series of refining operations above mentioned may be repeated on the molten metal before taking it out. This refining by repetition of the process may be necessary in cases where the phosphorus and sulphur were present in unusually large quantity or where a very high degree of refining is to be attained.

Another advantage of the electric furnace is that the molten steel clears itself of suspended particles of slag more easily and completely than is the case with either the open-hearth or the Bessemer process.

The oxygen of the air, in the open-hearth furnace, causes oxidation of the carbon in the molten mass, forming carbonic oxide gas bubbles; and these, as they escape, cause a boiling effect, which tends to churn the slag and mingle particles of it with the metal mass. On the other hand, in the electric furnace, the molten mass is less agitated and somewhat more fluid, by reason of the slightly higher temperatures produced; there is less tendency for slag particles to become mixed with the metal, and it is less difficult for the suspended particles to rise to the surface.

It is seen from what precedes that there are good reasons, from the metallurgical point of view, for the better quality of the steel produced by the electric furnace. Comparing the electric furnace with the crucible furnace, we find that it has important advantages: First it can treat a larger charge (from 1 to 10 tons or more), the crucible being limited to charges of from 75 to 100 lb.; second, the heat is applied directly to the charge itself, and, therefore, very efficiently, while

TABLE VIII—EXPORTS OF FRENCH ELECTROCHEMICAL PRODUCTS (METRIC TONS)

Exported to	Chlorate of Potassium	Chloride of				Nitrate of		
		Aluminium	Lime	Magnesium	Potassium	Lime and Cyanamide	Potassium	Sodium
Colonies	171	.....	179	4	169	477	193	1,641
Germany	67	.....	408	.....	.....	.....	.....	.....
Belgium	94	.....	3,896	.....	34	.....	235	3,412
Spain	17	.....	3,845	.....	.....	.....	77	1,050
Great Britain	244	.....	2,057	8	50	.....	176	3,518
Italy	132	.....	899	.....	.....	.....	.....	116
Switzerland	.....	.....	105	31	.....	312	16	478
United States	.....	.....	1,251	.....	.....	.....	.....	.....
So. America	47	.....	884	.....	16	.....	58	.....
Japan	730	.....	.....	.....	.....	.....	.....	.....
Other countries	245	....	303	17	2	....	197	18
Total	1747	....	13,857	60	271	789	952	10,232

TABLE IX—TABLE OF ELECTRIC FURNACES FOR MAKING STEEL IN OPERATION OR UNDER CONSTRUCTION IN FRANCE IN 1914

Type of Furnace	No. of Companies Using Same	Aggregate Capacity, Metric Tons	H.P.	Products
Heroult	5	10	....	Tool steel Billets
Heroult	2*	55	....	Castings
Schneider	1	2.5	....	Sundry
Girod	6	33.5	4600	Tool steel Billets Castings
Keller	7	19	2280	Fine steel Billets Castings
Chaplet	3	13	2200	Fine steels
Rochling-Rodenhauser	1	3	350	Fine steels Billets
Kjellin	1	1.5	400	Fine steels Billets

*Under construction. All the others were in operation.

in the case of the crucibles it is applied to the outside of a vessel made of refractory material, of low heat conductivity, and, therefore, in a much less efficient manner; third, while sulphur and phosphorus can be removed in the electric furnace, this cannot be done in the crucible. These advantages point to the probability that the electric furnace will, in time, demonstrate its ability to do all that can be done by the crucible furnace, not only as well but better, and, besides, much more cheaply. It has already pre-empted a field between the crucible and the open-hearth furnace, in which it is preferable to both of these for certain purposes.

A very interesting application of the Girod electric furnace which was observed at Ugine is its use in foundry work. At the time of our visit there several of the furnaces were in use for melting steel for making high-grade steel castings. The furnace charge consisted of steel turnings, shavings, trimmings, etc., with some scrap steel and also ingots, all used in certain proportions. The large proportion of small turnings and shavings in the charge was noted. The electric furnace has proved exceptionally useful for remelting this kind of scrap. Evidence of this was seen at several other places, where the same thing was also done. It is doubtful if the recovery of scrap steel can be obtained with as much success and at as low cost by any other method. The charge, after being melted, was subjected to a purifying and refining process, same as when steel is to be made from pig iron. The oxidation and deoxidation stages were gone through, the metal was sampled from time to time during the heat, the necessary additions of lime and other reagents were made at the proper time, the operation being continued until the sampling tests showed that steel of the desired kind and quality had been obtained, after which the molten steel was emptied from the furnace into ladles and conveyed to the foundry.

M. Girod has himself set forth the advantages of the electric furnace in steel foundry practice in a paper published by him on that subject in Metallurgical and Chemical Engineering for October, 1912 (Vol. X, pp. 663-665). The following quotation gives a summary of the merits claimed for this method: "The electric steel furnace is especially well suited for castings, since it offers the possibility of holding finished steel in the furnace as in a mixer and to tap it at intervals as desired into small ladles. Different taps can be made at different temperatures, lower temperatures being used for larger molds and higher ones for small castings. The steel can be heated to any desired temperature and castings can be made very thin-walled and of

a very small size. Pieces from ½ lb. and upward with sections of 7 to 7 mm. thickness can be cast without any difficulty. With the electric furnace one is sure to have for castings an absolutely dense steel without blowholes and pipes."

The steel castings seen in the foundry at Ugine were of the very finest quality and they indicated that the claims made for the method used were not unfounded. The results obtained at Ugine have led one of the largest steel companies in the United States to install a Girod furnace at one of its works. This may be regarded as further indication that this furnace is considered capable of industrial application.

Ferro-Alloys.—There is, perhaps, no application of the electric furnace in which it has been more successful than in the manufacture of certain alloys known as "ferro-alloys." France has played a leading part in the erection of this new branch of electrometallurgy. These alloys, composed of iron or steel combined with one or more metals, are of great importance in metallurgy. They have indeed been the means by which wonderful progress has been made in the manufacture of steel of higher grades and of special kinds suited for specific purposes. The ferro-alloys may be used in two ways, according to their properties, and the manner of their use. Some may be regarded as being in reality reagents; they are specially suited to serve as deoxidizers during the process of refining the steel; and, after serving this purpose, they pass out with the slag, leaving no trace in the steel. The others are true alloys; they are specially suited to enter into the steel as a permanent part of its alloy, which produces important changes in its hardness, and other physical properties. The same ferro-alloy may serve in one case the ephemeral purpose of a deoxidizer and in another case the permanent purpose of an alloy.

The ferro-alloys which are specially useful as deoxidizers generally include silicon as one of their constituents. The list includes: ferrosilicon, ferrosilico-aluminium, silico-manganese-aluminium, silicocalcium-aluminium, and silicomanganese. Of these, ferrosilicon is the best known and most used. The estimated total consumption of ferrosilicon in the world for 1910 was about 60,000 tons. At first this ferro-alloy consisted of "silicious" pig-iron made in the blast furnace from highly silicious iron. It was a weak deoxidizer because it contained only a small amount of silicon (10 per cent to 12 per cent, rarely as much as 15 per cent), with proportionately too much carbon, and also a considerable proportion of sulphur and phosphorus. The electric furnace has permitted the manufacture of a much richer and purer product. It is now made in various grades, suited for different purposes, with silicon contents ranging from 25 to 95 per cent. The grades containing from 25 to 30 per cent and from 45 to 50 per cent are those generally used for deoxidation purposes in steel refining. The 75 per cent and 90 per cent ferrosilicons are also used as deoxidizing reagents, and as alloy for making silicon steels for electric purposes.

Ferrosilicon of high grade (75 to 90 per cent) has also proved useful in foundry work. It is stated that by its use in varying proportions the characteristics of cast iron from the same heat can be so varied as to produce both gray and white castings.

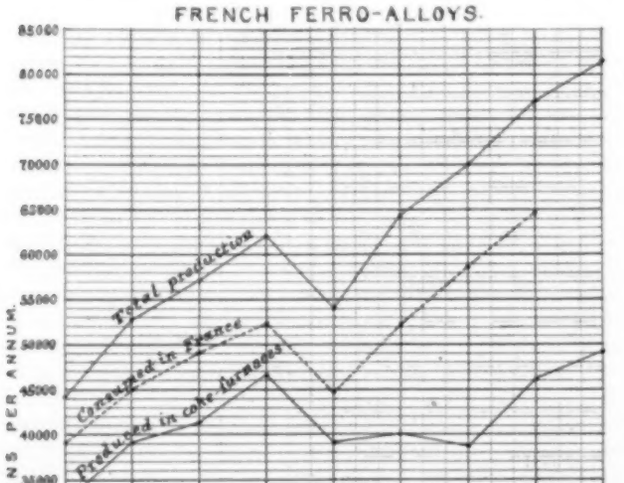
The other deoxidizing alloys serve for various special purposes.

The ferro-alloys of the second group include the alloys which are added to steels of various kinds and qualities in order to produce steels of great hardness, toughness, strength, etc., for making armor, or to produce "rapid" steels and special grades of tool steel. The principal ferro-alloys of this group are: ferrotungsten, ferromolybdenum, ferrovanadium, ferromanganese, ferrotantalum. These are all used in considerable quantity. Other metallic alloys used in smaller quantities include: ferroboron, nickel-boron, ferro-uranium, chromium-silicon, aluminium-silicon, manganese-silicon, aluminium-manganese-silicon.

There were in France before the war no less than 13 concerns engaged in this new electrometallurgical industry. One of these is the works of the Société Electrometallurgique Procédés Paul Girod, at Ugine, Savoie, adjoining the steel works already mentioned. This plant is one of the largest producers of ferro-alloys and rare metals in the world. It is a large producer of tool steels and of so-called "rapid steels." The total production of ferro-alloys in France in 1910 was 64,000 tons, of which a little less than half was made in electric furnaces. Since then the production by the electric furnace has been enormously increased.

Pure Metals. Besides producing ferro-alloys of the rarer metals, chromium, tungsten, molybdenum, manganese, etc., these metals are also produced as pure or nearly pure metals by electric furnace methods at many of the French electrometallurgical works. Thus refined chromium and manganese are produced, which contain less than ½ per cent of carbon. Chromium is also produced, containing higher proportions of carbon (from 4 per cent to 10 per cent). Commercial manganese, containing as high as 96 per cent of manganese, with 1 per cent to 2 per cent of iron and less than 2 per cent of carbon, is also produced by the electric furnace. Various alloys of two, three and four of the rarer metals are also produced, including the following: nickel-chromium, nickel-vanadium, copper-vanadium, nickel-molybdenum, nickel-tungsten, ferro-nickel-chromium, ferro-chromium-molybdenum, ferro-nickel-chromium-tungsten; in short, alloys of any kind and of any proportions desired for any specific purposes can be produced.

Zinc. There are deposits of zinc ores in the Pyrenees



FERRO-ALLOY PRODUCTION IN FRANCE

which have drawn attention to electrometallurgical methods of producing zinc, both by "electrolytic" and by "electrothermal" processes. A plant in operation at Arudy in the Lower Pyrenees is producing zinc-white containing 99 per cent of zinc oxide by the electric furnace. Another plant has recently been equipped, in the white-coal region, not far from Grenoble, to produce zinc-white from the same ore (zinc blende), by a process, also electrothermal, said to be more economical and efficient.

Other Metals. Considerable attention has been given, in France, to the search for practical methods, either electrothermal or electrolytic, for either producing or refining various metals of more or less usefulness in the arts, such as lead, tin, bismuth, antimony and magnesium. There is no evidence that industrial success has been attained thus far by any of them. There is, however, in operation, at present, in Grenoble, a plant for the production of pure iron by an electrolytic process which is attracting great attention by the remarkable properties and qualities of the iron produced. The process is specially adapted for producing iron sheets and tubes of any size. The samples seen leave no doubt as to the quality of the material. The cost of production is the chief point still in doubt.

Statistics. A few data of statistics are given in Tables I to IX, and some are also shown in diagrams (Figs. 1, 2, 3). Practically no statistics are available in the industries of electrochemistry and electrometallurgy for years later than 1912 and 1913. If such statistics were obtainable, however, they would be entirely unreliable and quite misleading. The fact is that both of these industries have been upset by the war to an extent which, in some cases, amounts to complete upheaval and transformation. This has been due to the necessity of diverting activity from the manufacture of products of less importance to those of greater, in fact of the greatest, importance for war requirements and purposes. It is fully realized, and was frankly stated several times to the commission, that war conditions are not considered a criterion of the outlook and prospects of any branch of these industries after the war. It is expected, in fact, that, even after the war, a certain time must elapse, to allow for a proper period of readjustment and rearrangement, in accordance with the conditions that will be then encountered, before statistics can be obtained that will be sufficiently free from the unbalancing and transitory effects of the war to give reliable indications as to the trend and possibilities of the development in these industries. Under the circumstances, therefore, the statistics available for the years preceding the war are the only ones that can be used as criteria, and these must be used with due reservation, in fact, with much care, as a basis for deductions and conclusions as to the future. Any one who has taken a close look at these industries in France is probably disposed to look for and expect some very interesting developments in them both, after the war.

The author desires to make special acknowledgment to the following persons: to M. Robert Pinot, General Secretary of the French Water Power Association, for the very full and valuable information, statistics, etc., placed at our disposal by him, so courteously and generously, in regard to the development and the status of the various electrochemical and electrometallurgical industries in France; to the manager and assistant manager of the Girod Works, at Ugine, Savoie, for the great pains taken by them to show the Girod electric furnace in every phase of its operation and to demonstrate its practical use for both making steel and steel castings.

Special thanks are due to M. Maurice Damour, Deputy—who was officially charged by the French Government with the organization and direction of the trip made through France by the American Industrial Commission—for his untiring zeal and efforts in assisting the members of the Commission, at all times, to obtain technical and industrial information, as well as in making the trip interesting, profitable and agreeable to the Commission; also to the distinguished delegation from the "White Coal Region" who assisted M. Damour in conducting the Commission through the various hydro-electric, electrochemical, and electrometallurgical plants visited by the Commission.

TABLES

The production of steel ingots by the electric furnace in the countries which give that product separately in their statistics is given in Table I. Table II gives the production of ferro-alloys in France, Table III the production of aluminium in different countries from 1903 to 1912, Table IV the production of cyanamide, calcium carbide, and calcium nitrate, Table V the production of calcium carbide in 1913, Table VI the exports of French ferro-alloys from 1903 to 1912, Table VII the exports of French aluminium, Table VIII the exports of French electrochemical products to different countries, and Table IX electric steel furnaces in France in 1914.

Niagara Falls Section of American Electrochemical Society.—The officers for the present year elected at the annual meeting of the Niagara Falls Section of the American Electrochemical Society are as follows: F. J. Tone, president; H. W. Kellogg, vice-president, and A. T. Hinckley, secretary-treasurer.

Lectures at College of the City of New York.—The following lectures, open to the public, are still to be given on the program of the Spring Lecture of the Chemistry Department of C. C., N. Y. (Dr. Charles Baskerville, director). Two lectures have already been given. They are given at 3 p. m. in the Doremus Lecture Theatre, 140th Street and Convent Avenue.

March 23, "The Conservation of Pine Forests Through the Methods of Chemical Research," by Dr. Charles H. Herty, past president, American Chemical Society.

March 30, "The Getting of Wisdom," by Dr. H. K. Mees, director Research Dept., Eastman Kodak Co.

April 13, "Colloids in Pharmacy," by Dr. John U. Lloyd, Cincinnati, Ohio.

April 27, "Some Chemistry of the Tropics," by Dr. L. H. Friëdburg, professor-emeritus, C. C., N. Y.

Meeting of Columbia Section of Mining Engineers.—The Columbia Section of the American Institute of Mining Engineers held a meeting at Spokane, Wash., on Feb. 23, as a part of the program of the 1917 Northwest Mining Convention. The following papers were presented:

"Advance in Methods of Ore Treatment During Last Five Years," by Prof. F. A. Thomson, head Department of Mining Engineering, State College of Washington.

"Experiments in the recovery of Tungsten and Gold, Murray District, Idaho," by Dr. R. R. Goodrich, professor of Metallurgy, University of Idaho.

"Progress Report on the Bunker Hill and Sullivan Smelter, Kellogg, Idaho," by a member of the staff.

Annual Exhibit at Ohio Northern University.—The College of Engineering of Ohio Northern University, Ada, Ohio, held its fifteenth annual exhibit and banquet during the week of Feb. 19-23. Lectures on technical subjects were given and the exhibit included drawings, models and machines, representing the work of the students throughout the year.

The Cottrell Process in Practice*

By Linn Bradley

It seems fitting that this Symposium on the Smelter Smoke and Fume Problem is being held at a joint meeting of the New York sections of the American Institute of Mining Engineers and the American Electrochemical Society. The Cottrell process is highly interesting to those who have to deal with problems in electrophysics or those involving the use of electricity at high potentials. The chemist and the chemical engineer are interested not only because of the value of eliminating nuisances and recovering materials now going to waste, but also because of the chemical problems attending the treatment of dust and fume-laden gases by electrical means. The metallurgist's interest is, of course, quite well known. For the members of the Institute, who are interested primarily in mining, the application of the processes should also have an interesting aspect, in that a new method of obtaining valuable ores has been devolped which has resulted in the conservation of large amounts of valuable material. The recovery of metals such as copper, silver, gold, zinc, lead and even platinum and bismuth, from the gases coming from smelting and refining operations may be looked upon as constituting a mining field which is in an embryonic state of development.

The smelter fume problem, from both legal and economic points of view, has been discussed in a thorough and able manner by the first speaker, Mr. Ligon Johnson.[1] The next question which arises is that of available methods for solving the technical problems involved in fume prevention or elimination, and it is under this latter heading that the Cottrell process is up for discussion.

In general the problems of fume prevention or elimination may be considered from two standpoints. First, that of the nuisance to the neighborhood; second, that of the values which are recoverable. This latter aspect involves also other economies in plant operation.

It has already been pointed out that sulphur-dioxide and sulphur-trioxide are of prime importance in any discussion of this subject. The large quantity of sulphur-dioxide to be cared for presents one of the most difficult problems. In considering sulphur trioxide, there should be kept in mind one of the facts with which we are confronted in applying the electrical processes. Generally, when sulphur trioxide is spoken of in a discussion of the fume problem, the compound referred to is not in reality sulphur trioxide, but sulphuric acid, H_2SO_4. At ordinary temperatures the gases do not contain the anhydride if moisture is present in sufficient quantity to combine with the trioxide to produce H_2SO_4. The white fume which is referred to as sulphur trioxide really consists of very small particles of sulphuric acid, the strength of the acid depending upon the amount of moisture present, the temperature of the gases and the length of time which has elapsed since the moisture and the sulphur compound have been in contact. This white fume or mist of sulphuric acid is readily collected by the electrical precipitation process. On the other hand, sulphur dioxide, being in the gaseous condition, is not collected, unless provisions are made for its absorption by some reagent previous to treatment in the precipitator and then precipitating the resulting compound.

Very extended and valuable investigations have been made by the smelting companies and by government bureaus looking toward the solution of the sulphur gas problem, and a large amount of useful and valuable data has been obtained. The sulphur must be disposed of in some manner. Converting the sulphur dioxide into elementary sulphur has been tried, and the purification of the gases and compression of the sulphur dioxide into a liquid has been suggested. Cheap methods of manufacturing sulphuric acid for use in the hydro-metallurgical treatment of low-grade ores offers great promise, and efforts which were begun by us a few years ago are now being pushed and it is hoped that results of considerable economic value will soon be made available to plant operators.

The application of the electrical precipitation processes to the recovery of dust and fume in smelters and refineries has already shown that the large losses of the past can now be prevented. The tendency at present is to avoid the construction in new plants, or the use in old plants, of large and expensive dust chambers, as these are now unnecessary. By concentrating all of the fume-collecting facilities at one point enough money has been saved in some cases entirely to pay for the expense of the new and more efficient installation. Furthermore, the transportation problem becomes simplified and it becomes possible to install apparatus for handling the fume in such manner that the health and happiness of the employees are promoted. This is of especial importance when considering fumes and dust carrying large quantities of lead or arsenic.

The treatment of the collected fumes, either chemically or metallurgically, so as to recover the contained values, will not be discussed in this paper because it should be considered as a separate subject.

In the western part of the United States are located most of the large smelters, the principal ones being devoted to the treatment of copper, lead, silver and zinc ores. At these smelters much attention has been given to flotation for some time past. The roasting of flotation concentrates may give high dust and fume losses, but the collection of this material is a comparatively simple matter, as far as the technique of the electrical precipitation processes is concerned. The gases submit readily to treatment, and the values in the collected material are sufficiently high to warrant the expense of a Cottrell precipitator installation and operation.

There are several smelters and refineries in the eastern part of the United States, some of which are located in or immediately adjacent to residence neigh-

*A paper presented in the symposium on the smelter smoke and fume problem at the joint meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society on Jan. 26, 1917. (See our issue of Feb. 1, 1917, p. 128.)

[1]This paper was published in our issue of Feb. 15, 1917, p. 199.—Editor.

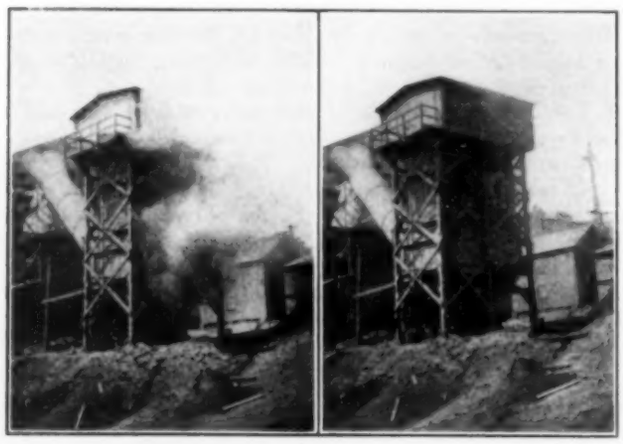


FIG. 1—COTTRELL PRECIPITATOR OF STASO MILLING CO., POULTNEY, VT.

For precipitating fine slate dust from the air from crusher building. The left picture shows the clouds of dust. The right picture was taken a few seconds after the current was turned on. 30,000 cu. ft. of air are handled per minute in this installation.

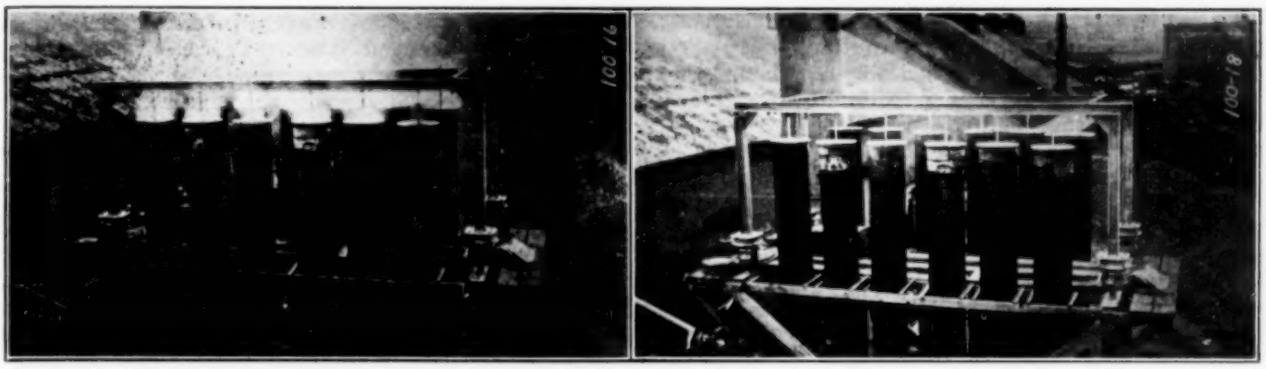


FIG. 2—COTTRELL PRECIPITATOR FOR PRECIPITATING FUMES OF ZINC OXIDE FROM THE GASES COMING FROM THE FIRES IN A BRASS CASTING SHOP, HANDLING 6500 CU. FT. PER MINUTE AT 600 DEG. FAHR. LEFT PICTURE—CURRENT OFF. RIGHT—CURRENT ON

borhoods. In these cases the nuisance problems, even when the plant is small, often become very acute and considerable effort is required in order to effect a solution.

There are many chemical plants, foundries and factories in the eastern section of the country at which the nuisance problem, as well as the problem of recovering values and improving sanitary conditions, are matters of great importance. The elimination of acid fumes, such as sulphuric, nitric, hydrochloric and even phosphoric, presents a great variety of interesting problems.

In factories it is often desirable to remove practically all the suspended dust particles from the air admitted to the rooms. In the operation of a sand blast equipment a large amount of fine dust is produced and this is best collected at a point near its source. In these foundry and factory problems, where the air is reutilized after treatment for the removal of suspended dust, the possible saving, due to the conservation of heat in the winter time, is of considerable importance.

The wide range of conditions which confront the engineer in connection with problems of this kind, readily shows the desirability of having a process capable of being applied to a great variety of conditions. The Cottrell process meets this requirement in a very admirable manner, as it can be operated throughout a wide range of temperature up to that at which insulating materials and metals lose their essential qualities, the one as to electrical features and the other as to mechanical strength. Corrosive substances can be readily handled since it is possible to construct the precipitator of material which will withstand corrosion.

Precipitation installations may be divided into two classes; first, those in which the solution of the problem is of such importance as to warrant high installation cost and in which it would be unwise to economize to too great an extent; and second, those in which the utmost economy is required, and in which it is highly desirable to make the operation of the precipitator as automatic and fool-proof as possible, so that the minimum of labor is employed. In some cases the installation is for temporary use only, and in such instances the plant should be designed with this in mind.

In order that a problem may be given thorough consideration, accurate and adequate data must be obtained. Some of the things to be determined are the minimum, average and maximum volumes of gas to be treated; the temperature and composition of the gases; the barometric pressure at the place where the installation is to be made; the origin of the gases; the size, type and arrangement of furnaces, flues, stacks, etc.; the nature and quantity of the fume or dust, and the type of electric power available at the plant. In some instances other information also is required. If such data are not already available an investigation at the plant is often necessary before the precipitation installation can be designed and constructed, as the precipitators generally are designed to fit special conditions in most of the important problems.

The Cottrell process seems to be very simple, and this idea of simplicity seems to be enhanced when one first sees the operation of a demonstration plant consisting of one small sheet iron pipe, say 6 in. in diameter by 8 ft. in length, with a No. 18 iron wire placed along the vertical axis of the pipe and kept insulated therefrom. The process works so simply and easily that it is very difficult to realize the ramifications of the work in practice. However, in spite of the fact that there are numerous features requiring careful study and analysis, it is well to keep in mind the thought of the simple pipe and wire and to avoid going off on too many tangents and ascribing difficulties, which may arise in connection with the work, to mysterious and complicated causes. As in the case of all new processes, a great amount of time and money has been spent upon the Cottrell process during its progress to the present stage in its evolution, and it has probably reached now the point where generalizations can be safely made. Furthermore, frankness in discussing difficulties and errors should be encouraged. It is true that many mistakes, both of commission and omission, have been made in the past, and that a vast amount remains to be learned and proved in practice in connection with the Cottrell processes. It is to be hoped that at this meeting the engineers and chemists present will volunteer to discuss the problems and troubles which they have encountered in their own plants, to the end that the general knowledge be promoted by the exchange of ideas based upon varied experiences.

The Cottrell process may be considered from two standpoints, for the purpose of this discussion, these being first, the electrical, and second, the mechanical. The electrical has to do with the circuit and the means for generating and controlling the high-tension unidirectional current for use in the precipitator. It is usually necessary to adapt the electrical equipment to the character of power available at the plant, and this dictates in a measure what electrical equipment will be installed. The mechanical features of the precipitation installation will be discussed a little later on.

Electrical Features of Cottrell Process

The alternating current may be obtained either from a motor-generator set, selected for the purpose, or from the plant circuit if the latter has suitable characteristics. In either case the alternating current is fed to a step-up transformer and the voltage raised generally to a point between 50,000 and 100,000 volts, depending

upon the local conditions. The high-voltage alternating current is rectified to an intermittent high-voltage direct current by means of a suitable rectifier. In case alternating current possessing suitable characteristics is available at the plant, the rectifier is driven by a small synchronous motor directly from the plant power circuit, but if a motor-generator set is required the rectifier is connected directly to the shaft of the motor-generator set and driven by it. The rectifier thus operates in synchronism with the current supplied to the transformer. In all cases a simple switchboard is provided for controlling the electric circuit.

Considerable improvement has been made in transformer construction with the aim of obtaining the most reliable apparatus for use with a circuit of this kind in which the electrical strains are much more severe and continuous than in almost any other service. The transformers are often rated at 10 kilovolt-amperes, 50,000 to 100,000 volts, high-tension, with the low-tension voltage at 200 or 400 volts. Usually a number of taps are brought out on the low-tension side so that the high voltage may be varied in steps between 50,000 and 100,000 in steps of about 5000 to 10,000 volts each. The provision of these taps is desirable even with a motor-generator set, but they are more essential when a synchronous motor is used. Some resistance is placed in the low-tension circuit to the transformer for two purposes, one being to obtain a closer control and regulation of the voltage than is possible with the taps alone, and the other being for the purpose of limiting the amount of current which can flow when a spark-over occurs in the precipitator. The electrical equipment, including the transformer, motor-generator set or synchronous motor, and the rectifier, should be protected against electrical surges. Inductances placed in the lines at proper points when used in conjunction with suitable resistances and ground connections, have very beneficial effects, the resistance in the high-tension circuit, used in conjunction with choke coils, is installed for the purpose of dissipating the energy due to surges, thus promoting steadiness and reliability of operation, and permitting higher voltages to be maintained.

Efforts to obtain light on some of the phenomena connected with electrical precipitation have been made in the past by means of an oscillograph, and in some cases valuable information has been obtained. It is necessary to be very careful in the use of an oscillograph, as the results are influenced sometimes in ways not expected. It seems that there are limitations to the use of the oscillograph for telling us the true story of what takes place in this type of electric circuit, the instruments at present available not being useful at the very high frequencies which sometimes occur in the circuit. However, even if the oscillograph curves were thoroughly dependable, their correct interpretation is not always simple.

The electrical equipment, of course, varies considerably in price, but some idea of its cost can be gained from the following: A 10-kilovolt-ampere, 100,000-volt equipment, consisting of transformer, synchronous motor, rectifier and switchboard, may be obtained for about $1,200 to $1,500. If a motor-generator set is required the cost will be considerably higher. The larger the power rating of the transformers and motor-generator units, the lower is the cost per kilowatt of capacity. This is especially true with the transformer, as a great deal of the expense is due to the insulation against the high voltage. The difficulty of continuously rectifying excessive currents makes it advisable to keep the power capacity of the electrical sets down to a reasonable value, say between 5 kilowatts and 50 kilowatts; although it must not be inferred that 50 kilowatts is the safe upper limit. In connection with an installation of serious importance, relatively speaking, it pays to purchase the very best equipment and to have patience until the same can be obtained, as it takes considerable time to obtain shipment on this class of material. As the work increases in volume, it becomes more and more possible to carry such electrical equipment in stock, and it seems that enough commercial installations have already been made to warrant this action.

A few words upon the question of synchronous motor versus motor-generator operation may be called for at this point. It has already been shown that the first cost of the motor-generator set is greater than that of a synchronous motor, and that one acts as a substitute for the other. With a motor-generator set the operator can obtain a very close control of the voltage, while with a synchronous motor the variation in voltage on the transformer is dependent upon the variation in voltage of the plant circuit, and if this varies rapidly or throughout too great a range, at the point where the transformer leads are connected to the local power line, the voltage in the precipitator will tend to fluctuate accordingly. This fluctuation may be prohibitive for successful operation, and it is thus obvious that the charactristics of the plant circuit, at the point where the power for the electrical precipitation installation is to be taken, should be thoroughly investigated and the future changes considered before the type of electrical equipment is decided upon.

Sometimes 25-cycle power is preferable to 60-cycle. This is the case when it is desirable to operate mechanical rectifiers in locations where it is difficult to maintain the insulation, as in acid plants, and it is therefore desirable to build the moving parts of the rectifier entirely of inorganic insulating material. In other cases, where it is desired to rectify very high voltage, the low speed of 750 r.p.m., usual with 25-cycle operation, as compared to the speed of 1800 r.p.m., with 60-cycle operation, permits the use of a rotating rectifier of greater diameter.

Investigations are being conducted with the object in view of improving the electric circuit and to further increasing the reliability and usefulness of the Cottrell process.

The operating conditions of the precipitators themselves affect the electric circuit. Some of the conditions which may be mentioned in this connection are leaky insulators, changes in gas composition and temperature, poorly built or poorly spaced electrodes, deposits on the electrodes, etc. All of these features should be carefully considered in designing the installation.

Mechanical Features of Cottrell Installation

The precipitator proper may now be considered from the mechanical point of view with special reference to the condition of the gases, the character of the dust and fume, and type of electrodes, the insulators, the effect on draft and on the operation of the furnaces, etc.

We have found that serious and baffling technical difficulties have been encountered in operation of large-scale precipitation installations, even when successful small-scale tests with the processes had been made before building the precipitator. After solving some of these difficulties and determining their cause we have concluded that even after it has been found possible to operate the Cottrell process satisfactorily on a given gas and fume with a single-pipe test precipitator, we should proceed to make tests under the entire range of operating conditions then existing or to exist in the plant. After concluding such tests the large precipitator for commercial operation in the plant should be so

designed, constructed and operated that no extraneous factors are introduced. In other words, efforts should be concentrated on making it certain that the conditions in each pipe of the large precipitator will correspond exactly with those in every other pipe, and at the same time be identical with the conditions encountered in conducting the tests with the single pipe. The slogan "Make every pipe a single pipe" has proven valuable, and has aided in keeping efforts properly directed.

Some of the factors which affect precipitator operation are as follows: Character of the dust and fume content of the gases; gas composition and temperature; gas speed and density; number and size of fume particles per cubic foot of gas and per unit of time per unit of electrode surface; the shape, size, length and composition of the electrodes; and the amount and character of deposit on the electrodes. Since all of these things have an effect on operation, if single-pipe tests have proved that satisfactory results may be obtained throughout the range of working conditions, the plant operator would do well to confine his efforts to insuring that all the gas and electrical conditions in each pipe correspond to those which were existant in the single-pipe tests. Unless these conditions are actually duplicated and not merely assumed to be so, one can well go astray and be a long time in obtaining the results which he seeks.

To illustrate how important this point of view is, suppose we have a precipitator containing several pipes each with its axially placed discharge electrode, and suppose that this precipitator has no upper gas chamber or header box, i.e., it is open at the top so that the gas passes from the upper end of each pipe directly into the atmosphere. One can readily understand that under certain conditions air can enter one or more of these pipes and pass downward through the pipe and then mix with the hotter gases in the lower gas chamber or header box, and thus produce a difference in the gas conditions in the pipes. That is to say, the gas in one or more pipes is different in temperature, velocity, fume density and composition, from the gases in other pipes. Unless the gases in all the pipes have the same characteristics in all respects it will be necessary to keep the voltage low enough to prevent sparkover in the gas which is, electrically speaking, the weakest.

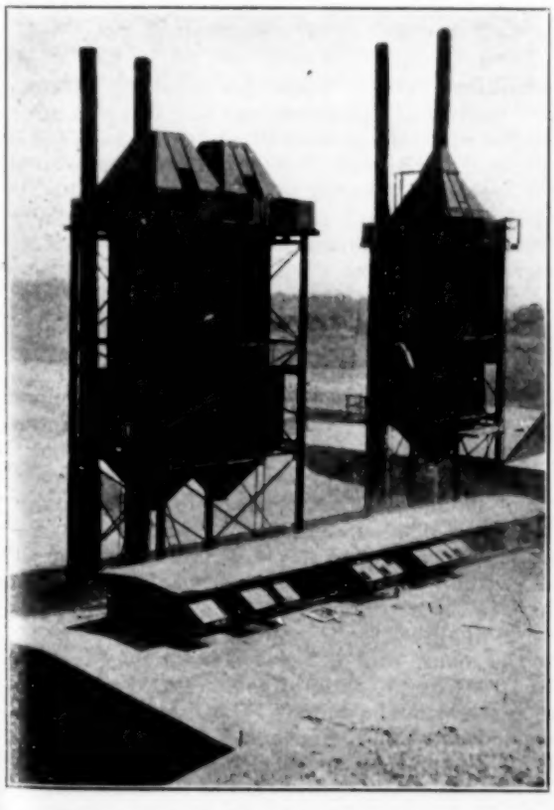


FIG. 3—COTTRELL PROCESS INSTALLATION FOR PRECIPITATING ZINC OXIDE FUMES FROM A BRASS CASTING SHOP
Precipitator units installed on roof of brass casting shop.

Suppose that there is an excessive temperature in even one or a few pipes of the precipitator, and that this condition continues for only a fraction of a minute at a time, but is occasionally repeated, it will be seen that the voltage which can be maintained in the precipitator as a whole will be limited to that which the weakest gas will permit, and this in turn affects the entire operation of the precipitator. From a study of the above facts it is plain that in order to obtain the maximum results from any precipitator the gases must be uniformly mixed and uniformly distributed through the various pipes and the precipitator built and operated in such manner that each pipe has exactly the same duties to perform, under identical conditions.

In an installation at a smelter in the west there was presented a very difficult problem and the technical results were very unfortunate because the truth of the facts just mentioned was not fully recognized. It is very difficult to investigate phenomena of this character in a large commercial precipitator, and one might say with reason that all such difficulties should be run to earth in the laboratory before an attempt is made to solve them in a commercial plant. Unfortunately, however, such problems as these have almost never presented themselves in laboratory investigations in the same manner as they have in the field, and we are confronted with the time-worn statement that "necessity is the mother of invention," so ingenuity is drawn upon in an effort to solve the problems. These difficulties have been carefully studied in connection with several commercial installations, and success has been finally obtained by proper application of the methods described above.

It has often been stated that the treatment of zinc fume by the Cottrell process presents problems peculiar to this metal, but our results in practice seem to deny the truth of such a statement. The phenomena which have been encountered in connection with the precipitation of the zinky fume from brass foundries have given us some very useful and valuable information, and owing to the fact that we have encountered similar phenomena in the treatment of fumes containing volatilized lime, potash, and even sulphuric acid mist, the conclusion seems warranted that zinc itself and its compounds do not possess any unusual and exclusive properties as far as electrical precipitation is concerned. Fig. 3 shows a precipitator in successful operation for collecting brass foundry fume containing as high as 60 per cent zinc, mostly in the form of oxide.

It having been considered necessary to look for reasons for the difficulty encountered in treating certain non-conductive gases, a survey was made of all the problems with which we have had any experience. One of our first clues came from some work we had conducted in connection with the precipitation of anhydrous tin chloride. We found that if we introduced the proper amount of steam and thoroughly mixed it with the gases prior to treatment electrically, precipitation was made very easy, while without the addition of this moisture good precipitation was impossible. The phenomenon was very striking. By a very slight turn of the steam valve so as to introduce just sufficient moisture, the operation of the precipitator was immediately changed and instead of a condition of violent

sparking steady operation with a good flow of current, such as is always desirable, was obtained. It occurred to us that the dehydrating action of the tin chloride had a very important effect upon the operation of the precipitator.

The same phenomena appeared when we started work on the precipitation of zinc oxide fumes, and after considerable investigation it was found that with the introduction of a proper amount of moisture in the proper manner, these fumes could be handled very successfully at temperatures even as high as 600 deg. to 700 deg. Fahr.

The mere introduction of moisture into the gases, however, does not suffice, as was found out to our bitter disappointment when we first made a test upon these gases after introducing moisture. It is necessary, according to our experience, if best results are to be obtained, to introduce the moisture in such manner that it becomes thoroughly mixed with the entire body of gases prior to subjection to treatment, and the installation should be so arranged that this uniformity of gas composition, fume burden and temperature is maintained for reasonable periods.

Cold and dry air, such as exists in the winter time, should not be allowed to enter any part of the precipitator, if the evidence from tests indicates that the resulting gas condition will necessitate a lowering of the voltage on the precipitator. This shows that even the geographical location of the precipitation installation, as well as the altitude, are important factors, as some have warm and moist atmosphere, while others have the opposite. In some cases the precipitator pipes should be enclosed to protect them from winds. If the precipitator has not an upper header, provision should be made to prevent wind sweeping down upon the open-ended pipes and creating uneven pressure zones above them, as this affects gas distribution, etc.

One of the most suitable methods for insuring uniformity of distribution in vertically positioned precipitator pipes is to place a specially designed orifice at the top of each precipitator pipe, thus creating a slight pressure difference, amounting to perhaps 0.05 to 0.10 in. of water, across these orifices when gases flow through them. The gases should be introduced into the bottom header and taken away from the upper header, if an upward pass is used, and vice versa if the gases pass downward through the pipes, in such manner that only slight pressure differences (static or kinetic) are created throughout the mass of the gases in the headers. These precautions will insure the gases flowing uniformly in each of the pipes, and will furthermore insure a uniformity of composition, temperature and fume burden if the gases have been thoroughly mixed, and this in turn makes it certain that the duty of each pipe is equal to that of each of the other pipes.

Sometimes it is possible to get good distribution of gases by the so-called down-flow type of precipitator. If the precipitator pipes are so arranged that heat can flow readily from the gas within the pipe to some substance without the pipe, the latter being kept considerably cooler than the former, a very even distribution of the gases may be obtained, but it must not be forgotten that the down-flow precipitators obtain their good distribution by a sacrifice of part of the heat energy in the gases, if reliance is placed on the difference in gas density due to a change in temperature.

The acid and moisture which is generally contained in the gases from smelters make their problems relatively easy from the standpoint of electrical precipitation, but it does not hold that a well-designed and well-constructed precipitator which proves highly successful in connection with one problem, can be installed at another place in connection with another problem, and be equally successful. In fact, it might prove to be an utter failure, as can be readily realized from an examination of the statements preceding. It will also be obvious that brute force and sledge hammer tactics will not insure success. Patience and accurate deductions are more in order.

In installing a precipitation installation it would be disastrous to overlook the fact that the furnaces or other sources of the fume are of primary importance, and nothing should be done which will interfere with their operation. Similarly the draft requirements as to intensity and regulation should always be kept in mind. The flues should be so constructed that the draft drop through them is made very small, and if any draft drop is to be tolerated it should be concentrated at a point in the precipitators where it can do the most good, namely, across the orifices if this method of obtaining uniform distribution is used. A great deal of useful information in connection with the engineering problems relating to the design of flues, etc., may be obtained by a study of the work which has been done by the engineers responsible for the solution of large ventilation problems in factories and elsewhere.

In conclusion it might be mentioned that there are many plants in commercial operation on the continent of North America, several on the continent of Europe, in England, some in Japan, Africa and South America, and the work is growing very rapidly. There are perhaps 100 to 150 people devoting their entire time to the work and more are being added to the force as rapidly as they can be absorbed and trained. Standardization of the methods of handling problems, and the design of standard apparatus is progressing and the work is being more effectively organized. The precipitators are divided into two classes, viz., those which are designed and built on special order, and those which are designed and built as stock units.

Research Corporation,
New York City.

Standard Screen Scale for Testing Sieves.—The U. S. Bureau of Standards has just issued a statement recommending the general adoption of a standard screen scale in the interests of securing uniformity of usage. This scale was adopted by a conference, called by the Bureau of Standards of representatives of various committees of the American Society for Testing Materials, American Society of Civil Engineers, American Institute of Mining Engineers, American Foundrymen's Association, Mining and Metallurgical Society of America, American Waterworks Association, American Institute of Metals, and the American Spice Trade Association; also representatives of the Committee of Revision of the U. S. Pharmacopœia, the U. S. Geological Survey, the U. S. Bureau of Mines, the U. S. Bureau of Public Roads and Rural Engineering, the U. S. Office of Grain Standardization, and the U. S. Bureau of Standards; also representatives of a number of private firms engaged in industries which employ sieves. The screen scale adopted is essentially metric. The sieve having an opening of 1 mm. is the basic one, and the sieves above and below this in the series are related to it by using in general the square root of 2 or 1.4142, or the fourth root of 2 to 1.1892 as the ratio of the width of one opening to the next smaller opening. The first ratio is used for openings between 1 mm. and 8 mm., while the fourth root of 2 is used as the ratio for openings below 1 mm. to give more sieves in that part of the scale. The sieves are to be designated not by the number of meshes per unit length, but by the width of the opening in millimeters, as a 1.41 mm. sieve or a 0.36 mm. sieve.

Synopsis of Recent Metallurgical and Chemical Literature

Iron and Steel

Effect of Sulphur on Low-Carbon Steel.—At the recent annual meeting of the American Institute of Mining Engineers, in New York City, Prof. CARLE R. HAYWARD, of Massachusetts Institute of Technology, read a paper describing some experiments on the effect of sulphur in various steels. He refers to a previous paper by Dr. J. S. Unger, of the Carnegie Steel Company, in which the conclusion was reached from a long series of experiments that "the author does not advocate paying no attention whatever to sulphur content in steel, but believes firmly that a steel containing less than 0.100 per cent is not necessarily bad, and that it will show little, if any, difference in quality when compared with the same steel of much lower sulphur, other conditions being the same."

The conclusions reached by Prof. Hayward are as follows:

"The summary of the tensile tests shows that the high-sulphur steel has for each treatment the highest breaking load while the yield point ranks first for two treatments, second for three and third for two. From this we may conclude that the sulphur does not lower the tensile strength.

"The figures for elongation and reduction of area show that there is little difference in ductility between the low and medium-sulphur steels, but the ductility of the high-sulphur steel is slightly lower than the other two for most of the treatments.

"The average figures for the shock tests, except for the air- and furnace-cooled specimens, are highest for each treatment in the case of the low-sulphur steels and lowest for each treatment for the high-sulphur steels. The widest difference appears in the steels which have been quenched and reheated.

"It is difficult to draw definite conclusions from the results because of the newness of the shock test and the difference of opinion among engineers regarding its value. The tensile tests are not unfavorable to steels with moderate amounts of sulphur, while the shock tests show a decided falling off in strength as the sulphur increases. Until the interpretation of the results from the Charpy machine is more fully understood, it is impossible to say to which set of tests the most importance should be attached.

"Further light might be thrown on the subject by making alternate stress or fatigue tests. It would be important to learn whether the results would confirm the tensile or shock tests. Unfortunately, however, the stock of steels used in the previous work was exhausted, and whatever the results of the fatigue tests there would be an uncertainty in their interpretation because of difference in stock. It was, therefore, decided not to include this series in the present investigation.'

Heat Treatment of High-Speed Tool Steel.—In a paper presented at the New York meeting of the American Institute of Mining Engineers, February, 1917, A. E. BELLIS and T. W. HARDY present a discussion and some results of experiments in treating high-speed tool steel in which metallographic means were used in determining the correct hardening temperatures. The authors state that in order to be on the safe side the average tool hardener uses a temperature much too low to give the best results with the high-speed steel he uses. In the case of cutters which are finished to a given diameter before hardening, it is impossible to grind the tool after hardening, so that it is essential that the surface be protected from oxidizing or de-carbonizing.

The analyses of the steels used in the tests are as follows:

ANALYSES OF HIGH-SPEED STEELS USED IN HARDENING TESTS

	C. Per Cent	W. Per Cent	Cr. Per Cent	Va. Per Cent
A	0.58	17.4	3.11	1.14
B	0.60	13.3	3.32	3.58
C	0.53	13.0	4.69	2.45
D	0.75	17.7	3.30	0.85
E	0.60	16.5	3.55	0.70

Six specimens from the same bar of each kind of steel were hardened from different temperatures, and photomicrographs made. The six samples were taken from the same bar in the annealed condition regularly furnished the tool maker. Photographs were made of the longitudinal section, care being taken to grind off the outer surface. The specimens, ¼-in. square in section, were first preheated at 1500 deg. Fahr., and then quickly placed in the high-speed furnace already heated to the desired temperature, left at this temperature for 1 min. and quenched in oil. The temperature was controlled by a standard pyrometer, consisting of a rare-metal couple and potentiometer. An optical pyrometer of the Holborn-Kurlbaum type gave excellent checks with the standard pyrometer, and proved more convenient and durable. A precision of 10 deg. Fahr. was attained throughout. The polished specimens were etched for 15 min. in 4 per cent alcoholic solution of nitric acid, and photographed.

In general, the steels that show some excess carbide even at the maximum hardening heat are the most efficient. These, as a rule, are the steels with high tungsten content; they harden from a higher temperature and over a wider range than the lower-tungsten steels. For this reason they do not require as careful treatment and are, therefore, more popular than the lower-tungsten steels. The steels with lower tungsten and higher vanadium give better results when hardened at the lower temperatures than do the higher-tungsten steels when these are hardened at the same low temperatures, but the comparison is not so advantageous to the lower-tungsten steels when the steel with higher tungsten is given the proper hardening heat.

The importance of carefully controlling the hardening temperature, and of varying it for the particular steel used, cannot be overemphasized. The custom of using one "high-speed temperature" for all tools is very poor practice, for, as shown by the photomicrographs, the best structure may be obtained with one steel at a temperature which will "burn" another, or not harden a third. Thus 2300 deg. Fahr. or over is necessary to give A or E a good structure, but this temperature gives a coarse grain in the other steels, or "burns" them. Again, a temperature as low as 2150 deg. Fahr. can satisfactorily harden *B* or *D*, but tools made of other steels would not stand up if hardened at this temperature. More extreme examples could have been shown, but the samples chosen are typical of the most widely used brands of high-speed steel.

The average hardener rarely obtains the best result from his steel. The reason for this is, especially in the cases of tools that cannot be ground after hardening, that oxidation becomes a serious problem at higher temperatures. The use of a barium chloride bath to eliminate this difficulty has the disadvantage that the surface of the tool becomes decarbonized. A method that has proven satisfactory is to place the tools after preheating in the reducing atmosphere of a carbon resistance electric furnace already heated to the required temperature. The very short time necessary to get the tool to the temperature of the furnace eliminates deleterious surface effects. Pack hardening often gives good results but, owing to the great affinity of iron for

carbon at high temperatures, care must be taken to reduce this carbonizing action to a minimum. This may be done by selecting a packing material of little or no carbonizing power, and by cutting down the time during which the metal is in contact with the packing material.

The increased efficiency and cutting power of tools that have received the proper heat treatment is out of all proportion to the time given to the study of the particular steel involved, and to the care given the work.

Seasoning of Castings.—In a paper presented at the New York meeting of the American Institute of Mining Engineers in February, RICHARD MOLDENKE, of Watchung, N. J., discusses the "seasoning" of castings. He states that it is one of the little-known characteristics of cast iron, which nevertheless has an important bearing on results where accuracy in machining is essential. It is the ability of this material to ease up internal strains when allowed to remain quiescent for a more or less extended period of time. It seems as if the molecules in such a casting, by virtue of their "mobility," can adjust their relative positions to an extent sufficient to overcome some of the existing stresses.

Every engineer knows the danger of water-hammer in pipe lines, particularly if the latter are of cast iron. Every mechanic knows, or should know, that it is not good to strike a fitting that is under steam pressure. The author discusses the two kinds of reduction in volume in a casting, viz.: that due to the change from the liquid to the solid state, and the reduction in volume after setting until ordinary temperatures have been reached. He discusses seasoning as follows:

"Every mechanic knows that in planing up a slab of cast iron on both sides to get a true job it is necessary to take a light cut, reverse, and take a cut on the other side, then reverse again for the finishing cut, finally reversing for the last cut. If this is not done there will be warped surfaces to deal with on account of the internal strains. Again, it is well known that to get a true piston is a rather difficult matter. Even after grinding to a finish it is apt to get out of true. It is not so generally known, however, that if such a cast-iron plate or piston is allowed to remain in storage for a long period, the results will be much more satisfactory. The castings have "seasoned." Where establishments are familiar with the situation, orders for castings are placed far ahead of requirements. Since, however, on getting to the bottom of a big pile the difficulty of tracing defective work becomes correspondingly harder, only shops having their own foundries are likely to do much storing. The present demand for very high-class machined castings, as evinced by automobile cylinders, pistons, engine and compressor cylinders, etc., should bring this question of 'seasoning' out very prominently. Inquiry by the writer has shown but little knowledge on the subject in the trade generally, though where first-class foundrymen were connected with the industries involved, these were very much alive to the matter. In general, the difficulty seems to be the inability of storing up ahead, or when so doing of striking defective product when least expected, particularly in such cases as castings for piston rings, etc. For what seems the best indirect explanation of the 'seasoning' action, we are indebted to the well-known metallurgist, A. E. Outerbridge, Jr., who in his famous experiments on 'tumbling' castings to increase their strength, found that by the action of light blows, often repeated, the internal strains were relieved to such an extent that the real value of the metal came into play. The 'mobility' of the molecules was aided by artificial means. Incidentally, however, the tests establish the 'mobility' of the molecules in cast iron very satisfactorily. Replace half-an-hour's tumbling by 6 months' quiescence and the molecules will have done their work with somewhat the same results. In view of the possible depression scheduled for this country on the close of hostilities in Europe, would it not be well to ease up operations slowly instead of shutting down tight. This would help the industrial situation adjust itself more safely and at the same time stock up supplies of castings which will be all the better for having seasoned. Inasmuch as similar improvement has been noticed in the case of ingots, billets and other iron-base products, the same argument would hold. The writer presents this memorandum in the hope that a discussion may bring out present practice and possible applications with respect to an almost unknown but highly valuable characteristic of cast iron and allied materials."

Effect of Time in Reheating Hardened Steel.—At the recent New York meeting of the American Institute of Mining Engineers, Prof. CARLE R. HAYWARD and S. S. RAYMOND, of the Massachusetts Institute of Technology, read a paper describing some experiments on reheating hardened steel below the critical range. The experiments were made with the object of finding the effect of time on reheating. The steels used were practically all of the same composition, the average analysis being, C, 0.45 per cent; Si, 0.03 per cent; Si, 0.49 per cent; Mn, 0.54 per cent; P, 0.015 per cent. The specimens were heated first to 800 deg. C. and then reheated in sets of three for 15 minutes, 30 minutes, one hour, two hours and 4 hours, at 300 deg. C., 400 deg. C., 500 deg. C. and 600 deg. C. An electric resistance furnace was used. After the heat treatment the specimens were tested in an Olsen machine for tensile strength and were also tested for hardness. Microscopic examination of the specimens did not show enough difference in the various samples to make their reproduction of interest. The results indicate that for reheating quenched medium carbon steel to temperatures below 500 deg. it is only necessary to heat it through. Longer heating has little or no effect on the tensile strength, ductility or hardness. At temperatures above 500 deg. increasing the time of treatment causes a slight falling off in hardness and tensile strength with a corresponding increase in ductility. Curves constructed from the results show that for the 15 minutes heating the ultimate strength falls about 25 per cent and the yield point about 20 per cent as the temperature increases from 300 deg. to 600 deg., and the same figures hold approximately true for the one-half hour, one-hour and two-hour treatments. Heating for four hours causes the ultimate strength to fall about 30 per cent and the yield point about 25 per cent as the temperature increases from 300 deg. to 600 deg.

Strontium

Production of Strontium in the U. S.—In the *Mining and Oil Bulletin* (Los Angeles Chamber of Mines and Oil) for February, 1917, B. W. JAMES presents some data on the production of strontium ore and compounds in this country. He states that it was not until after the first year of the European war had elapsed, and a shortage of the nitrate developed, that the attention of our chemists was called to the fact that Germany had been our sole source of supply while we had workable deposits of ore as yet undeveloped. In April, 1916, the price per pound was suddenly boosted to 54 cents as against the 6½ cents prevailing some months earlier. The largest consumers are the fireworks and railway fuse manufacturers. A quick scout-

ing for material showed that the only workable deposits were of the sulphate, or celestite, in Arizona and California, and incidentally that such deposits were inconveniently located in desert countries far from transportation. In the past few months some nitrate has been made from ore from an isolated deposit in San Diego County with a 40-mile wagon haul. There is also a very promising deposit in the Avawatz Mountains, but at present is too far away for operation. Another deposit, 15 miles south of Gila Bend, Ariz., was placed within 2 miles of a shipping spur by the completion of the Calumet & Arizona's new railroad to the Cornelia properties at Ajo. The chief associated ingredient is silica, which is inert and harmless. Some ore has been sold during the past year and it is expected that much more will be used, as several companies have negotiated for a supply. However, the owners look forward to a great demand following the adoption of the strontia process in the manufacture of beet sugar, which effects a saving of 6 per cent to 8 per cent of the saccharine content of the molasses over the methods employed at present. The Geological Survey reports that Germany and Russia each use 100,000 tons per year of strontium hydroxide for this purpose and that the process is also applicable to cane sugar. The German supply is obtained from the carbonate, strontianite, which may be calcined to a caustic condition similar to quicklime, being then in a condition to use in the extraction of sugar. The indications are that this ore supply is diminishing and that celestite will later be used to some extent. Contrary to various reports, strontium is not used in the manufacture of high explosives, although much of the nitrate is used in "tracer shells" and by the various navies in signals.

Recent Chemical and Metallurgical Patents

Nickel

Extraction of Nickel in Electric Furnace.—A process for producing nickel, or ferronickel from garnierite, a hydrous nickel magnesium silicate, is patented by MICHAEL A. REBERT of York, Pa. The furnace design presents no unusual features. It is cylindrical and vertical with a rounded bottom and having one top and one bottom vertical electrode. Metal and slag spouts are provided in the proper places. Calcium fluoride is first charged into the furnace and melted by striking an arc. The garnierite or other ore to be used is then gradually added and is melted and becomes mixed with the calcium fluoride. The current liberates fluorine at the anode from the calcium fluoride, and this combines with the silicon of the ore, liberating the nickel. The calcium is constantly renewed, the nickel is tapped from the bottom of the furnace and the slag from near the center. To liberate the fluorine at the anode, a direct current must be used, though it is stated that alternating current also gives good results, no complete explanation being given. (1,215,857, Feb. 13, 1917.)

Quartz Glass

Manufacture of Quartz Glass.—Simplifications in the method of manufacturing quartz glass are described in a patent of OTTO C. TRAUTMANN of New York City, which he has assigned to the Sidio Company of America, of New York City. Formerly in producing quartz glass objects it has been necessary to introduce a blast of air into the interior of the plastic quartz body before it has had a chance to cool. This required the introduction of pipes and apparatus in the interior of the furnace which is impractical, due to the extreme heat. The present invention has for its object to devise a process whereby the vessel may be blown without any special apparatus and without requiring any handling, involving loss of time. In carrying out the process, the quartz is first fused in an electric furnace consisting of a shell 10 lined with suitable heat-resisting material 11. The base of the furnace is closed by a conductor 12 and at the top of the furnace is a conducting head 13 between which is positioned the resistance core 14. The latter is reduced in section as at 15. The quartz sand is introduced into the furnace, the resistance core is properly clamped in place and the current turned on. The plastic mass of quartz 17 soon forms about the core. When the requisite amount of plastic is formed, a door 18 at the bottom of the furnace is opened, permitting the surplus sand to escape. The two movable parts 19 and 20, having a concavity 21, 22, are actu-

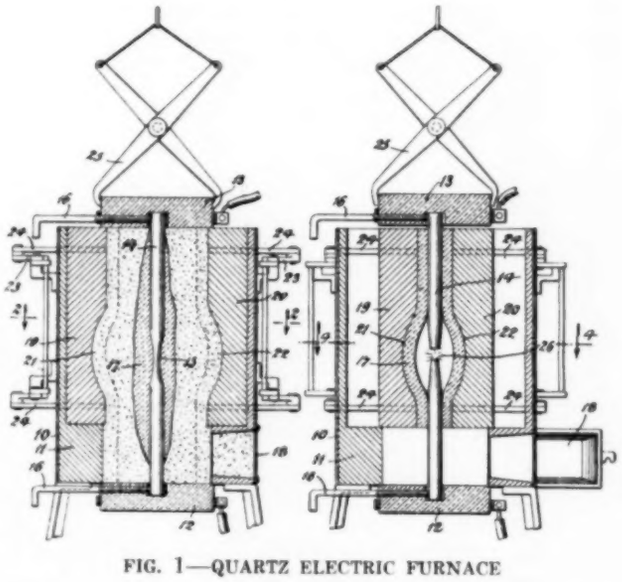


FIG. 1—QUARTZ ELECTRIC FURNACE

ated by levers 23 and rods 24. The concaved portions 21, 22 form a mold about the plastic as illustrated in the right-hand section. It is now necessary to produce an interior pressure so as to expand the plastic into the mold. This is accomplished as follows: The upper portion of the resistance core 14 may be twisted or strain otherwise applied, as by means of the tongs 25, so as to break the core at the weakened portion 15. The portions of the core may then be separated slightly, forming an arc 26, as clearly appears in the right-hand illustration. The gases generated by the arc then produce a pressure sufficient to force the plastic into the mold. (1,215,433, Feb. 13, 1917.)

Polishing Iron

Composition for Polishing Iron.—A metal polish for removing rust, etc., from iron is patented by MATAICHI YASUDA of Koishigawa, Tokyo, Japan. An example of the composition of this powder is as follows: powdered metallic alluminium 2 parts by weight, dehydrated alum 3 parts, finely powdered crystalline silica 5 parts. The powder is applied to a water-soaked cloth and rubbed steadily on the surface of the iron to be cleaned and polished. The polished surface is then wiped off, and water and suitable grease applied to preserve the polish. (1,216,643, Feb. 20, 1917.)

Ferroalloys

Electric Furnace.—An electric furnace especially suitable for melting ferroalloys is patented by HECTOR DE NOLLY of St. Chamond, France. The patent is assigned to the Société Electrometallurgique de St. Beron of Lyons, France. A cross-section of the furnace

is shown in Fig. 2. It consists of a hearth *B* of large section, forming the lower part of a fusion chamber. Connected to this hearth by channel *D* is a fore-hearth *C* of smaller section. The slag is formed in the hearth *B*, and does not pass into the fore-hearth *C*. Large positive electrodes *A*, whose end surfaces almost cover the surface of the hearth *B*, and negative electrodes *E* in the fore-hearth are provided to heat the charge. The level of the charge is kept a little below the overflow spout *H*, and when it is desired to use some of the molten alloy, one of the electrodes *A* is lowered deeper into the molten mass, thus forcing the desired amount out of the spout. A switch is provided by which one of the positive electrodes can be reversed in polarity for temperature control purposes. It is claimed that on account of "the slag contained in the furnace being

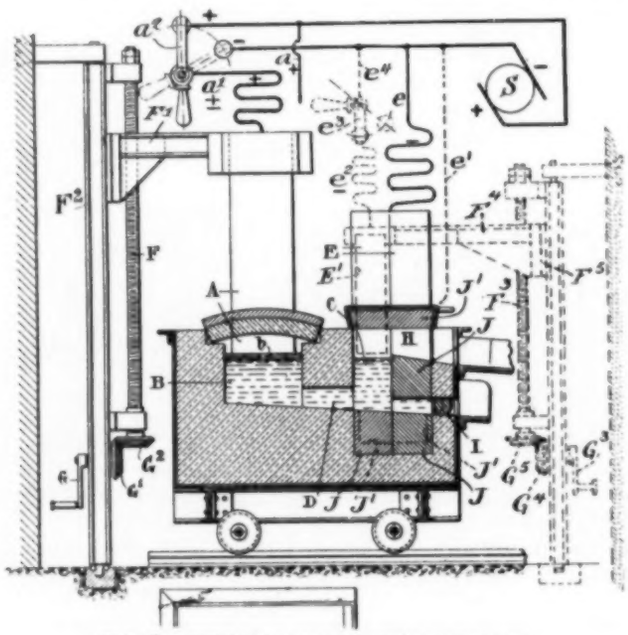


FIG. 2—FERROALLOY ELECTRIC FURNACE

always the same there is no inconvenience in its presenting any desired thickness, and this consideration, in conjunction with the employment of a low voltage, explains the possibility of avoiding volatilization almost completely, even in the case of highly volatile metals such as manganese zinc and so forth, because the arc proper can always be disestablished and the furnace operated in series" (1,216,961, Feb. 20, 1917).

Combustion in Hand-Fired Furnaces.—An investigation of the conditions governing the process of combustion in the fuel bed of a hand-fired furnace has been made by the Bureau of Mines and the results just published as Technical Paper 137. The first part of the paper contains general information on the combustion of coal. A series of about fifty tests made in a small experimental hand-fired furnace are then described, using Pittsburgh coal, anthracite coal and coke. The rate of combustion varied from 20 to 185 pounds of fuel per sq. ft. of grate per hour. Two thicknesses of fuel were used, 6 in. and 12 in. The results are collected in about forty charts showing the composition of the gases, the temperature at different depths in the fuel bed and various relations between the air supply and rate of combustion. Other data are included, on the composition of gases rising from the fuel bed of a hand-fired furnace under a steam boiler, a Murphy stoker, and a Jones underfeed stoker. A short discussion is also given of the bearing of the results on the operation of gas producers and explosions in boiler furnaces.

Notes on Ball Milling with Special Reference to the Marcy Mill*

By F. E. Marcy

Ball and pebble mills have been used in this country for more than fifty years. They are a very simple device, so simple in fact that the means of improvement are limited as compared with more complicated or complex machinery. During the period of fifty years many suggested improvements and patents have been taken out and forgotten for want of not being carefully worked out and commercialized. It has been a popular machine for cement work for a long time and is still standard both here and abroad. Its form is cylindrical, short for coarse crushing using larger balls, and longer for fine crushing using pebbles or small balls. In order to save space combined mills have been built using large balls at one end and small at the other with a slotted partition between. None but cylindrical mills are used and no other geometrical shape has been adopted by the large cement users in this country.

Cylindrical pebble mills have been extensively used in cyanide work for the last twenty years, and for the last six or seven years pebble mills have been used in grinding for concentration. The ball mills have never become popular in this country and were very little used in ore milling until quite recently. As an illustration, the Inspiration in their first test mill, in 1912, under the direction of Mr. J. M. Callow tried cone mills with steel balls and gave it up as a failure. The Miami Copper Company tried and carried on extensive experiments, 1911-1912, with a cone mill and steel balls and they gave it up also on account of the high costs. It was a surprise, particularly to those who knew the conditions, when it was announced that Inspiration had adopted Marcy ball mills. Prior to this time, namely, February 1, 1915, the largest tonnage that was treated with ball mills in any ore plant was at the Golden Cycle, where kommuters were used in crushing coarse ore from 3 in. to ¼ in.

During September and October, 1913, at the Butte and Superior plant at Butte, a test was conducted between a 7 in. x 10 in. cylindrical and an 8 in. x 22 in. cone mill. The results of these tests convinced me that the cylindrical mill was the one of the future.

I will not take the time to go into details of the development of the Marcy mill, of my failures and troubles, or describe to you the breakages and disappointments that the mill caused the companies that bought them, nor will I mention what my competitors had to say through their advertisements, but I desire to set forth a few fundamental facts in crushing with rotatable containers charged with balls or pebbles and then describe the principle of the Marcy mill. Finally I will describe briefly what this mill is doing and some of the experiments that are now being conducted to further its usefulness.

1. In crushing dry in a pebble or ball mill the fines aggregate at the periphery of the mill, due to the sifting action and the angle of repose of the falling mass due to the rotation of the mill. In wet crushing the fines are found near the top of the pulp and not at the periphery and the discharge of the fines from the mill is like a tank overflow. The tendency of all overflow trunnion mills is to over-grind the heavy particles or the mineral content.

2. The discharge of the finished product near the periphery of the mill or through a point at right angles to the pulp flow tends to give a product in which the mineral contents of the mill have not been subjected to

*A paper presented at a meeting of the Mining and Metallurgical Society on February 15th.

the classifying action, or in other words all products, regardless of the gravity, have more of an equal chance to escape from the mill.

3. Thick pulp in a mill, as 30 per cent water and 70 per cent ore, increases the efficiency of the mill, for the liners of the mill and the balls or pebbles become coated with particles of ore and wherever there is contact, crushing is produced, this tending to increase rapidity of grinding and decrease wear on steel and pebbles. It is not possible to use such high consistencies or such thick pulp in pebble mills with overflow trunnions, for at this consistency small pebbles will float and discharge from the mill unless there is a screen or grate to keep them in.

4. Finished pulp in a mill or ore which has been reduced to the required fineness should be discharged at once. If it remains in the mill after being ground to the required fineness it not only retards the actions of the balls for useful work, but the mineral is subjected to unnecessary sliming action. For this reason as it costs but little to separate the finished from the unfinished product outside the mill it is better to do this and return oversize rather than to attempt to finish the crushing in one pass. One pass crushing is, therefore, inefficient both because of the loss of work in overcrushing and the unnecessary sliming of mineral.

5. Whether we use Rittinger's or Kick's law the work to be done becomes very much greater as we crush finer and wherever there are particles or ore that come in contact with the metal points work in crushing is produced. Therefore, theoretically the mill should increase in diameter as the ore advances through the mill in order that the crushing energy be increased as required for the work to be done.

6. That in crushing in a closed circuit for fine sizes as floatation or all sliming for cyanide the fineness is determined by the overflow of the classifier and when crushing in such a manner with graded balls, and coarse ore that forms a compact and flexible mass, the length of the mill has nothing to do with the fineness of the product.

7. The rapid removal of a finished product from the mill when crushing in a thick pulp depends upon the difference of head between the intake and the outlet and the amount of pulp contained in the mill. Mills that overflow at the trunnion are necessarily slow in discharging their entire load on account of the large quantity contained within. Such mills are like a mill dam in a flowing stream.

8. That in taking primary crusher product and feeding to a ball mill making a product passing ⅛ in. mesh or 60 mesh is effective and efficient. As to the relative efficiency between this and two or three stage crushing is a matter of space, of capacity, of flexibility and cost of crushing the material. If power, liners, balls and labor cost nothing it would make very little difference what type of mill was used or the number of stages adopted in crushing.

Now the Marcy mill is designed for crushing coarse ore taking a primary feed, say 3 in. or 4 in., and crushing it all through ¼ in. or ⅛ in. with one pass of the mill. It is designed also to take the same feed and crush it through 20 x 30 mesh when operating in closed circuit with a screen or hydraulic classifier. When taking this coarse feed and operating in closed circuit with a mechanical classifier, as the Dorr, it will crush so all will pass through 50 or 100 mesh. The mills are shorter than the diameter. A number 86 mill is 8 ft. in diameter and 6 ft. long. A 64½ mill is 6 ft. in diameter and 4½ ft. long, etc. Various types of liners have been used, but in general the mills are equipped with Krupp type made of manganese steel. The entire discharge end is fitted with grates made of grizzly bar section. The spacing or the discharge of the ore is set for 3/32, ⅛ or 3/16 in., depending on what product is desired. Back of the grates and next to the discharge end radial lifters carry the pulp up and discharge it through the trunnion. Thousands of dollars have been spent in the development of this grate. It is made of rolled, high-carbon, tempered chrome steel. The spacing for the passing of ore is maintained by small pads that are on the bars themselves and are placed during the last pass of the rolls when the bars are made. There is a slight bevel to the grates toward the discharge end so that the sand will not clog in passing. In the actual operation of the mill the pulp line is about ¼ of the diameter of the mill. The height of this pulp line is maintained by the amount of water entering the mill. A very slight turn of the water valve will raise or lower the pulp, more water lowers the pulp line and thick pulp has the opposite effect. It would seem that any mechanical device for fixing the pulp line is superfluous and shows a lack of knowledge regarding the actual requirements.

In a short time there will be treated over 50,000 tons ore daily with Marcy mills, working under various conditions. Among the most notable installations are the Kennecott Copper Corp., the Braden Copper Company, the Doe Run Lead Company, and the Inspiration Copper Company. I mention these, as they are all typical and the mills are one size. The mills are equipped with 3/16 in. grate or opening between the bars and when operated so that the ore passes the mill only once they have had a capacity of 1100 dry tons per 24 hours each, taking coarse feed. Other mills with coarse feed and operating in closed circuit with a Dorr classifier have crushed in an excess of 500 tons per day each, with 3 per cent on 48 mesh.

The entire end of the Marcy mill is covered with a grate and the actual area of the actual 3/16 in. openings in the grate for the ore to pass is 1100 square inches. The inside diameter of the trunnion is 12 in. and the area is 113 square inches, consequently we have the grate discharge area nearly 10 times that of the trunnion discharge area. I am of the impression that the discharge is not restricted. The grates, as now manufactured, tempered and held securely in place, do not blind and the ore at all times when reduced to the proper fineness discharges freely.

At the Inspiration mill, when treating 500 tons per day of the original feed, there is approximately 1600 tons that pass the grate, due to the circulating load. The 36 mills that are now in operation at Inspiration have a daily capacity of 17,000 dry tons per 24 hours. There are no other ball mills or pebble mills in use at this plant. As noted, there will be installed shortly two cone mills that were furnished the Inspiration Company without cost under the guarantee that they would have an equal capacity as the Marcy mill and do an equal amount of work within very much less horsepower. Whether these cone mills come up to their guarantee remains to be seen.

Since the installation of the Marcy mill at the Magna Copper Company, the Inspiration Company and the Utah Copper Company, my design has been copied and appropriated by a number of manufacturers without my consent. The system of crushing advocated by me at the Inspiration plant has been extensively used since its installation and success, and I hope it will prove all that is expected of it. We are now endeavoring to simplify and improve this mill wherever possible. This necessarily means a vast amount of experimenting and the cost is large to the companies who are carrying on these experiments.

We have designed liners for the shell that are made in

solid pieces. They are like a large roll shell, 8 ft. in diameter and 6 ft. in length and 5 in. in thickness made in manganese steel. We have designed, and it has been adopted as standard, a one piece end liner made of manganese steel and weighing 2½ tons. Such liners and such pieces can only be handled in big installations where they have the services of a traveling crane and where the mill can be knocked down to receive these parts. We expect the future liners and grates at Inspiration to last nine months of continuous service. We are endeavoring to increase the efficiency of the mechanical classifier and to increase the efficiency and effectiveness of the balls themselves, hoping to satisfy the operator whose problems are capacity, costs and metallurgical results. In my opinion this type of mill has come to stay, for its principles are in accordance with the fundamentals of wet crushing.

RESULTS OF MILLING DURING THE MONTH OF AUGUST, 1916, AT THE INSPIRATION CONSOLIDATED COPPER COMPANY

Details of screen analysis.

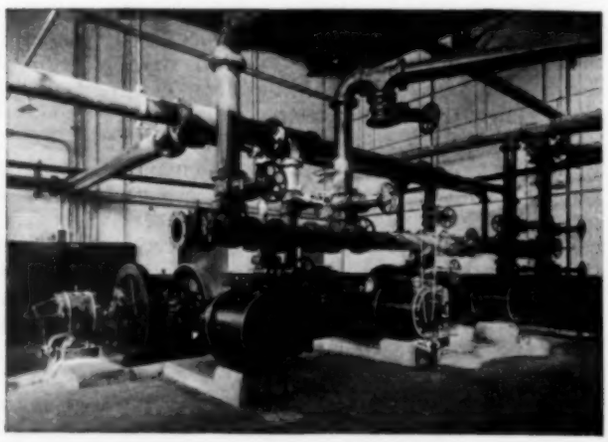
	Feed to Ball Mills	Product
On 1.5-in.	17.7	
On 1-in.	16.5	
On ⅜-in.	24.7	
On 3 mesh	7.3	
On 6 mesh	7.7	
On 8 mesh	2.2	
On 14 mesh	4.8	
On 28 mesh	3.6	
On 48 mesh	2.9	2.9
On 65 mesh		7.9
On 100 mesh	2.3	12.6
On 150 mesh		12.6
On 200 mesh	1.5	5.8
Through 200 mesh	8.8	58.2
	100.0	100.0

The kilowatt-hours required per ton ore increase grinding, conveying and sampling	0.409
The number of kilowatt-hours required per ton ore in fine grinding in Marcy ball mills, divided into the following:	
Power for conveyor, D	
Dorr classifier and cranes	0.18
Power for Marcy ball mills	9.68
	9.86
Average tonnage ore ground per Marcy mill in 24 hours	475

Fumigating Baled Cotton by the Hydrocyanic Acid Gas Process

Since the revision of the rules and regulations which govern the importation of cotton lint into the United States, effective Feb. 1, 1916, the fumigation of imported cotton has become a live industry. Among the companies organized to enter this new field The Vacuum Company, incorporated under the laws of Massachusetts, was the first to get its plants in actual operation, having one plant in Somerville, Mass., and another in Brooklyn, N. Y.

The object of the disinfection of cotton is to destroy the larvæ of the ping boll worm, which is a native of India, the Orient and Hawaiian Islands. The eggs which it deposits in cotton seeds hatch to life and feed on the seeds for a period as long as seven months. The present cotton disinfecting plants are built to carry out the method of disinfection prescribed by the Horticultural Board of the Department of Agriculture on March 22, 1916. This method, briefly stated, requires that the unmanufactured cotton and cotton waste must be placed in a suitable fumigating chamber where it is subject to hydrocyanic acid gas under certain definite conditions.



VACUUM PUMPS AND PIPING FOR FUMIGATION OF COTTON

In generating the gas lumps of cyanide of sodium are placed in a steel basket in the mixing tanks and dissolved in the proper amount of water. This solution is then raised from the mixing tank to the cyanide measuring tank by vacuum. Sulphuric acid is then drawn directly from the carboys, also by vacuum, and the two liquids in the proper proportions are introduced into the generators where their union causes the formation of hydrocyanic acid. The gas thus formed passes from the generators through cartridges of cyanide of sodium and limestone to absorb completely any free sulphuric acid. It is then drawn into the retorts. After the gas has been used in fumigation it is pumped out of the retorts and passed through a spray washing machine, where it is broken and the cyanide replaced. Two large vats, containing caustic soda solution, are used in connection with this reclamation, one being used until it has been saturated, when the process is transferred to the other vat. Continuous circulation is maintained through the spray washer while pumping out the gases.

To fumigate the cotton, all bales after being trucked by hand from the freight cars on the sidings to the platform cars are moved into the retorts and the doors and gates closed. The retorts are then subjected to a vacuum of 25 in., after which the hydrocyanic gas is introduced until the vacuum is decreased to 5 in. This condition is maintained for one and a half hours, when the gas is again exhausted to a 25-in. vacuum; then after sufficient washing with air to eliminate any danger of escaping gas the cotton is removed from the retorts, sorted and reloaded on cars for shipment.

In operating the cylindrical retorts the platform cars are loaded alternately from either end, so that while one train of cars is being unloaded and loaded again, another loaded with cotton is in the retort being fumigated. These retorts permit a very efficient and time-saving system of handling. The entire layout of vacuum pumps and piping is such that any combination of pumps and generators may be used on any or all the retorts at one time.

The Brooklyn plant of The Vacuum Company is operated in the same manner as the one in Somerville, Mass. It is of smaller capacity, containing one rectangular retort 42 ft. long. An additional retort and pump are, however, being installed at the present time so that the capacity of the plant will soon be doubled.

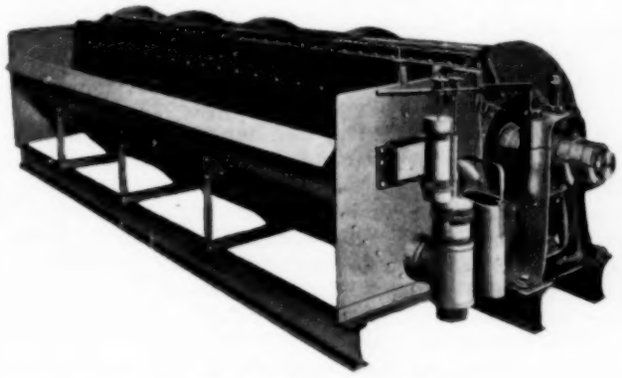
Studies, plans and specifications for both Somerville and Brooklyn plants of The Vacuum Company were prepared by Charles T. Main, engineer, of Boston, Mass. Herbert L. Sherman of the New England Bureau of Tests, Inc., and Arthur D. Little, Inc., acted as consulting chemists.

A New Flotation Machine

The K & K Flotation Machine, made by the Southwestern Engineering Co., Los Angeles, Cal., consists of a cylindrical housing about 10 ft. long and 30 in. in diameter, as shown in the accompanying illustration. To the front part of this is attached a "V"-shaped compartment called the frothing-chamber. The frothing-

chamber is provided with a lip, over which the concentrates are discharged into a suitable launder.

Inside the cylindrical housing or aeration-chamber is located the rotor which consists of a 3 7/16-in. steel shaft, on which is mounted four pressed steel spiders, which carry the lagging and riffles of the rotor. The rotor is supported by two main bearings located at each



K & K FLOTATION MACHINE

end of the machine. The lagging forming the periphery of the rotor is so spaced as to leave a ¼-in. opening or slot between each piece—there are 16 of these pieces and each piece is provided with four hardwood riffles, which run the entire length of the rotor which is about 10 ft. long. The rotor revolves at 180 r.p.m. and has a clearance of ⅜ in. between its outside periphery and the inside surface of the aeration-chamber.

The shaft on which the rotor is mounted passes through the two end plates of the machine by means of two air ducts 14 in. in diameter and 13 in. long. These air ducts are ample size to furnish all the air from atmosphere necessary to thoroughly aerate the pulp as it is revolved between the outside riffled surface of the rotor and the inside surface of the aeration-chamber. There is no leakage of pulp through these air ducts, and there is a continuous influx of air from the atmosphere. This influx of air is discharged by centrifugal force through the air slots between each of the 16 pieces of riffled lagging forming the periphery of the rotor and immediately comes in contact with a thin film of pulp which has been circulated by the revolving rotor.

The frothing-box is provided with suitable partitions and openings which cause (together with the level control device), the skimming of a thin film on the surface of the riffled rotor. This thin film is supplied with air which passes in through the air ducts at each end of the machine and out through the air slots of the rotor, coming in contact and thoroughly aerating the revolving pulp in the space between the outside periphery of the rotor and the inside surface of aeration-chamber.

The pulp enters at one end of the machine and is discharged at the opposite end, while passing through the machine a distance of 10 ft., it is also caused to revolve through the aeration-chamber. This longitudinal and rotary action causes the feed to move in the path of a helix during which course it is thoroughly aerated, forming a froth which carries the mineral, and discharges same over the lip of the frothing-chamber, while the tailings are discharged at the other end of the machine. An adjustable level control device is provided which maintains the proper level of pulp in the machine, which in return furnishes the correct height of the bubble column in the frothing-chamber.

As can be seen from the above description, the feed enters at one end of the machine, the tailings are discharged at the opposite end, while the concentrate is discharged over the lip of the frothing-chamber into a suitable launder. The machine, therefore, is a complete unit in itself, receiving the pulp at the intake, aerating and frothing same, discharging concentrates over the lip of the of the frothing-chamber, and finally discharging the tailings at the opposite end of the machine. All this is carried on in one operation, which is continuous, the machine itself furnishing a horizontal and circular path for the feed, during which aeration takes place, frothing is produced, and tailings and concentrates are discharged.

The steel machine is constructed of No. 10 steel plate, with end pieces of ¼-in. plate mounted on a structural steel base composed of three 5-in. I-beams, on which are fastened the two main bearings. The housing over the rotor is constructed of rolled plate re-enforced with angle bars, and is so arranged that it can be removed for the replacing of the hardwood riffles which last from four to six months. The steel machine is recommended for feeds which contain no excessive acid which might be detrimental to such construction, and in cases where excessive acid is present wooden type is provided. This machine is built in the same general design, being entirely of wood, with the exception of the shaft, spiders and bearings.

Each machine is provided with a pulley for driving from a line shaft, but may also be driven by direct connection to electric motor or other power.

The machine is a complete unit, requiring no blower, air compressor nor pre-agitation. The floor space required is 4 ft. by 14 ft., and the head room about 3 ft. The capacity of the machine is 80 to 150 tons per 24 hr., and requires from 8 to 10 hp. to operate. The weight of the steel machine is 3500 lb., and the weight of the wood type is 2500 lb.

Automatic Temperature Control

The Bristol Company of Waterbury, Conn., have developed a new line of automatic temperature controllers for gas, oil fired and electrically heated furnaces. The principle of operation of these controllers is to employ three elements: the measuring element, the contacting element, and the operating element.

The measuring element may be any type of pyrometer or thermometer.

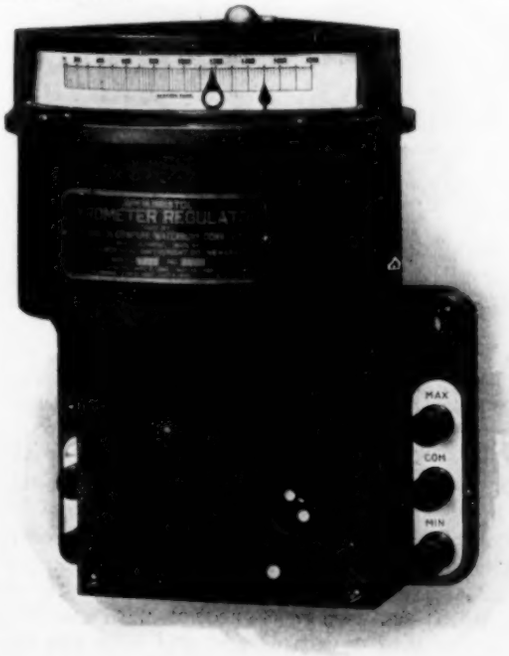


FIG. 1—EXTERNAL VIEW OF THERMO-ELECTRIC TYPE

The controlling element is combined with the measuring element and consists primarily of a patented electrical contact closing device which operates at predetermined high and low temperatures, and by means of this electrical circuits are closed or opened, thus energizing or disconnecting the operating element.

The operating element consists of the device which actually regulates the heat supply in the furnace, as,

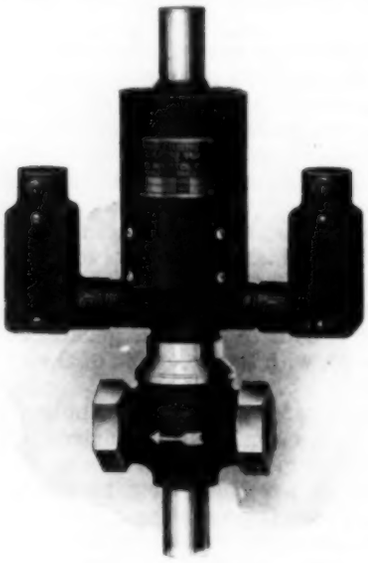


FIG. 2—GAS AND AIR VALVE

for instance, in the case of a gas-fired furnace, a pair of electrically operated gas and air valves, and in the case of an electric furnace it consists of a special relay switch opening and closing the circuits of the heating element of the furnace.

Fig. 1 shows an external view of the measuring and controlling elements of the thermo-electric type. The indicating arm is completely insulated from the operating circuits and the contacting device is frictionless. These controllers are made for all temperatures up to

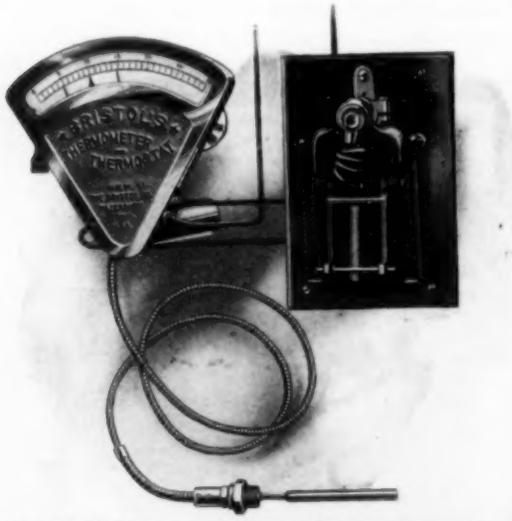


FIG. 3—VAPOR TYPE THERMOMETER-THERMOSTAT

3000 deg. F. and with high-resistance movements for use either with base or precious metal couples.

Fig. 2 shows one of the special gas and air valves, two of which are used in connection with gas furnaces if air is supplied at a pressure, and both gas and air valves are operated simultaneously so as to insure having the proper mixture at all times.

Fig. 3 shows one of the vapor-type thermometer-thermostats, with sensitive bulb and connected to the special relay switch employed for adapting these instruments to the control of temperatures in electric ovens and furnaces.

Book Reviews

The American Petroleum Industry. Vols. I and II. By **Raymond Foss Bacon,** Ph.D., and **William Allen Hamor,** M.A. Price, $10. New York: McGraw-Hill Book Company.

This is a most interesting and important contribution to the literature on petroleum by the director and assistant director of the Mellon Institute of Industrial Research of the University of Pittsburgh. In conjunction with their work other specialists in specific fields have been called upon to write particular chapters for which they are best qualified. They are F. G. Clapp, E. E. Greve, Roswell H. Johnson, J. P. Cappeau, and L. G. Huntley.

In the preface to their work the authors state their purpose to be "to produce a treatise which would present a comprehensive survey of the American petroleum industry, distinctly modern in every respect, and suitable not only as a general reference work for those engaged in the industry, but also as a text-book for students of petroleum engineering. For these reasons, the subject matter is essentially descriptive, without, however, omitting the theoretical considerations necessary for the proper understanding of the subjects included."

The subject has been taken up in the following order:

Chapter I—The Geochemistry of Petroleum.

Chapter II—The Geology of Petroleum (by F. G. Clapp).

Chapter III—The Distribution of Petroleum in the United States.

Chapter IV—The Physical and Chemical Properties of Petroleum.

Chapter V—The History of the Petroleum Industry in the United States.

Chapter VI—Oil Well Technology.

Chapter VII—The Valuation of Oil Properties (by Roswell H. Johnson).

Chapter VIII—Some Commercial Factors Involved in the Appraisement of Petroleum Properties (by J. P. Cappeau).

Chapter IX—Possible Causes of the Decline of Oil Wells and Suggested Methods of Prolonging Yield (by L. G. Huntley).

Chapter X—Efficiency in the Production of Petroleum (by Roswell H. Johnson).

Chapter XI—The Condensation of Gasoline from Natural Gas.

Chapter XII—Refinery Technology.

Chapter XIII—Special Refinery Technology.

Chapter XIV—Refinery Engineering.

Chapter XV—Hygienic Considerations.

Chapter XVI—Some Problems of the Petroleum Industry.

Chapter XVII—The Shale-Oil Industry.

Chapter XVIII—A Glossary of Bitumenology.

The chapter on the geochemistry of petroleum summarizes the various theories of the inorganic and organic origin of petroleum in a clear-cut manner. The general conclusions as to our present state of knowledge follows: "Nearly all of the proposed theories to account for the origin of petroleum include certain elements of truth; in regard to some of the theories, considerable experimental proof has been forthcoming. Sokolov's cosmic hypothesis is sustained by the fact

that hydrocarbons are found in meteorites. The volcanic hypothesis is supported by the fact that hydrocarbons occur among volcanic emanations. The organic origin of petroleum, however, seems to be best maintained by the geological relations of the hydrocarbons. On the whole, the Engler-Hofër dual theory has the largest number of adherents, to whom the evidence seems to be clear that no important petroleum field derived its hydrocarbons from purely inorganic sources."

David White has considered the ingredient materials of coals and oil rocks, the biochemical and dynamo-chemical processes of alteration of the organic detritus, its devolatilization, its regional alteration and the corresponding regional differences in petroleums, and the occurrence of higher rank oils in regions of greater alteration of the carbonaceous residues. His conclusions are as follows: (1) Petroleum is a product generated in the course of the geodynamic alteration of deposits of organic débris of certain types buried in the sedimentary strata. (2) The quantity and characters of the oils generated are determined by (a) the composition of the organic deposit at the beginning of alteration; (b) the stage in the progress of this; (c) the elimination of the heavier and more viscous hydrocarbons through filtration incident to migration. It is probable that the composition of the mother organic deposit largely regulates the types of oils; it may account for the nitrogen and sulphur content, color, etc. (3) The rank of the oils is proportional to the degree of alteration of the carbonaceous deposits. (4) The change is marked by concentration of hydrogen in the distillates and of carbon in the residues. (5) Abnormally light oils are in most cases due to filtration. (6) In general, the oils found in successive underlying formations are progressively higher in rank. (7) In regions where the progressive devolatilization of the organic deposits in any formation has passed a certain point (usually 65-70 per cent fixed carbon) commercial oil pools are not present in that or underlying formations, although gas may occur. (8) Wherever the regional alteration of the carbonaceous residues passes the point marked by 65-70 per cent of fixed carbon in the pure coals, the light distillates appear in general to be gases at rock temperatures.

Campbell, who has considered the available evidence in a searching manner, states that this testimony favors the animal origin of most petroleum, although a certain amount has probably been derived from the fatty portions of plants. Some authorities contend that oils having an asphalt base are derived from animal matter and oils having a paraffin base from vegetable matters. Still other adherents of the organic theories claim that the differences in quality of the oils are due to differences of capillarity, heat, pressure, extent of migration, etc., but none of these theories seems to have been proved.

Richardson has recently expressed the opinion that the phenomena of surfaces and films, as demonstrated by the recent developments of colloidal chemistry, open up an entirely new point of view for the interpretation of the origin of petroleum and asphalt, and one which will be, no doubt, widely developed in the future. It seems to Richardson that the origin of all forms of petroleum must be attributed to surface action between a natural gas and the "sands," using this term in a general sense, with which it comes in contact.

The chapters on "The Distribution of Petroleum in the U. S.," "The Physical and Chemical Properties of Petroleum" and "The History of the Petroleum Industry in the United States" summarizes quite thoroughly the condition of these three phases of petroleum. "The History of the Petroleum Industry" is especially fascinating in showing its development from distribution in ounce bottles of crude petroleum for medicinal purposes to the giant industries summarized in the companies of the Standard Oil group; the authors give the various companies, the date and place of incorporation, their capital stock, and the type of marketing for each company and the ownership of various pipe lines.

The chapter on "Oil Well Technology" is profusely illustrated with clear cuts pertaining to drilling methods and appliances.

The chapter on "The Valuation of Oil Properties," by R. H. Johnson, gives an excellent outline of the logical method of procedure in the valuation of oil lands.

L. G. Huntley has contributed an important chapter on the "Possible Causes of the Decline of Oil Wells and Suggested Methods of Prolonging Yields." He summarizes this decline under the following heads:

1. Formation of waxy sediments that obstruct the passage of oil from the sand.
2. Decline of gas pressure in the district; that is, decrease of expulsive force, due to the exhaustion of the lighter and gaseous hydrocarbons.
3. Decrease in quantity of oil draining by gravity down the dip into the area affected by a well.
4. Decrease of the oil supply within the drainage area of a well on account of near-by development or the original limits of the pool.
5. Flooding by non-encroaching salt water under low pressure.
6. Flooding of the productive formation by salt water under high pressure.
7. Flooding by fresh water from the surface or from an overlying water-bearing formation.
8. Drilling of neighboring wells.
9. Poor management, such as improper casing, unwise rate and time of pumping, and failure to clean.

"The Condensation of Gasoline from Natural Gas," Chapter XI, is much too short for such an important subject as natural gas condensate. It can well be expanded in a future edition considerably. This is in part overcome by the rather full bibliography given.

The chapters on "Refinery Technology" and "Refinery Engineering" bristle with detailed information as to plant equipment and methods of operation. Full prints of actual refineries built upon actual specifications are given in these chapters. The subheads of these three chapters, indicate their scope and breadth.

The Refining of Petroleum.
The Dry- or "Cracking"-Distillation of Paraffin-Base Petroleum.
The Dry- or "Cracking"-Distillation of Mid-Continent Petroleum.
The Fractional-Distillation of Petroleum with the Aid of Steam.
The Operations in Some Pennsylvania Refineries.
The Manufacture of Paraffin Wax.
Petroleum Products Manufactured in the Appalachian Field.
The Operations in the Refining of Asphalt-Base Petroleum.
Petroleum Products Manufactured in the Mid-Continent Feld.
The Value of Oklahoma Petroleum.
The Products of California Petroleum.
California Oil Refineries and Topping Plants.
The Distribution of Petroleum Products to the Trade.
Systematic Methods of Testing Petroleum Products.
The Processes of "Sunning" and "Reducing."
The Dehydration of Petroleum.
The Continuous Distillation of Petroleum.
The "Cracking" Process.
The Chemical Treatment of Petroleum Distillates.

The Desulphurization of Mineral Oils.
The Decolorization of Petroleum Distillates.
The Production of Asphalt by the Oxidation of Petroleum.
Petrolatum.
General Specifications.
Reservoirs.
Tanks.
Stills.
Condensers.
Agitators.
Paraffin Wax Plant Equipment.
Miscellaneous Refinery Equipment.
Fire Extinction.

A special chapter on "Hygienic Considerations" in refineries gives welcome information. The prophylactic measures necessary for the well being of refinery workers are stated in clear-cut language.

"Some Problems of the Petroleum Industry" indicates quite clearly some of the urgent points in petroleum work crying for solution. No reader of the work can fail to find hundreds of problems calling for urgent clarification. This solution would require scientific work of the highest integrity, which could readily be carried on in our institutions of learning, and which would not be simple Uhlan work, but would call for the highest skill and capabilities of any physical, organic, or inorganic chemist in our universities. It may be that some of our institutions of learning will install specific courses in hydrocarbon chemistry, much as some have developed courses on ceramics, tanning, etc., which call for high scientific work.

The shale-oil industry is taken up at some considerable length, mainly from the Scottish point of view, as most of the work along this line has been done in Scotland and plants are in actual operation there on large-scale production. For America this subject is of great significance from the viewpoint of the rapid depletion of natural oil wells. For the day is not far distant when large shale-oil plants will be installed to recover the ammonia content for fertilizing and war purposes, and the oil content for the various purposes for which petroleum is used.

A glossary of bituminology closes the book. The glossary is quite complete and it is of value in clarifying the various terms which are used in different parts of the industry.

This work by Bacon and Hamor is a scholarly contribution to the petroleum industry of America. It covers in an "up-to-date" manner the subject in full. A tremendous amount of library and plant research has been carried on by the authors to bring together all available information upon the subject of the American petroleum industry. It will in all likelihood fulfill the ideal of the authors, stated in the preface, and will be used as a text-book in the classroom, and further as a reference book. Being ably written and authoritative, the treatise will fulfill a need and should be on the shelf of any worker in the petroleum oil field.

GUSTAV EGLOFF.

Handbook of Chemistry and Physics. Fifth Edition, 1916. 414 pages. Price $2.00. Cleveland, Ohio: The Chemical Rubber Company.

This little handbook is designed to be a ready-reference pocket book of chemical and physical data. The material is compiled from the most authoritative sources such as the Chemiker Kalender, the Landolt-Börnstein-Meyerhoffer tables, and a large number of text-books and other reference works. The material is condensed and is well indexed.

The present fifth edition is a revision of the previous one under the direction of Charles B. Hodgman and M. F. Coolbaugh of the Case School of Applied Science. A new and more complete table of gravimetric factors is included and the following tables have been added: heats of formation of important compounds, an anion analysis scheme, flame and bead tests, natural logarithms, algebraic formulæ, elementary derivatives and integrals.

Personal

Mr. **Enoch A. Barnard** has joined the instructing staff of the Department of Mining and Metallurgy of the University of Wisconsin for the second semester ending in June. He is on a leave of absence from his position as assistant testing engineer at the Washoe smelter, Anaconda, Mont., and will return on the completion of his work at Madison, Wis.

Mr. **Jay A. Carpenter** has resigned as metallurgist for the West End Consolidated at Tonopah, to accept the position of superintendent of the Nevada Packard mines at Rochester.

Mr. **Fred G. Farish** has resigned as manager of the Lluvia de Oro Gold Mining Company to take up the management of the Mineral Hill Consolidated Copper Co., Tucson, Ariz.

Mr. **C. A. Filteau** has resigned as manager of the St. Lawrence Talc Co., Natural Springs, N. Y., to become manager of the National Mines, Ltd., Cobalt, Ontario.

Prof. **Henry M. Howe** has been awarded the John Fritz Medal for 1917 for his investigations in metallurgy, especially in the metallography of iron and steel.

Mr. **Walter Laib** has been appointed superintendent of The Ohio Salt Company at Rittman, Ohio. This plant has a daily salt capacity of 5000 barrels, in addition to its production of chlorate of potash, manufactured under Mr. Laib's patent.

Dr. **Arthur D. Little** addressed the Canadian Manufacturers' Association and the Royal Canadian Institute at Toronto, on Dec. 1 and 2 last, respectively. A long abstract of his addresses, which were both on the same subject, "Scientific and Industrial Research," was printed in National Progress, a Canadian monthly magazine, for January.

Dr. **Morton G. Lloyd**, formerly technical editor of the Electrical Review and Western Electrician, has accepted a temporary appointment as associate electrical engineer in the Bureau of Standards, Washington, D. C., where he will be occupied with the various public utility investigations in which the Bureau is engaged.

Mr. **J. H. McCreery** has been elected secretary and treasurer of the newly organized firm of Ophuls, Hill & McCreery, consulting engineers of 112 West Forty-second Street, New York. Mr. McCreery will specialize in mining and mechanical engineering. The firm will make a specialty of appraisals of industrial power plants, also ice and refrigerating plants.

Mr. **Francis C. Ryan**, superintendent of Midland Recoveries Co. of Hammond, Ind., has been appointed chief electro-metallurgist at the U. S. Bureau of Mines station at the University of Washington. He will conduct research work in the use of electricity in metal working in the university laboratories. Dr. **Dorsey A. Lyon** is chief of the recently organized Bureau of Mines station at Seattle.

CURRENT MARKET REPORTS

The Iron and Steel Market

The actual course of the steel market appears to have diverged very materially from the appraisal generally made of it. The German peace proposal of Dec. 12 was assigned as a potent factor in quieting the market, while the holidays and usual year-end adjustments could be counted upon as an influence, and finally the observation was vouchsafed that the German declaration of unrestricted submarine warfare, beginning Feb. 1, was another cause, or explanation, of the quiet market.

There has been ample explanation for an assumed fact, but the question raised in the past ten days is whether any such fact existed. It now appears that bookings by the mills have been quite heavy since the first of the year, and the testimony of market prices, so far as it is acceptable as evidence, is loud and emphatic. In the week ended March 10 the increase in the average price of finished steel products was by a large margin the greatest for any week in the history of this steel price movement, extending now over a period of more than two years. March 5 all the regular wire products, including wire, barb wire and nails, were advanced $4 a ton, while iron and steel pipe, line pipe, O. D. pipe and oil country goods were also advanced $4. On March 8 the Carnegie Steel Company advanced bars and shapes $7 a ton and plates $15 a ton, other mills immediately following. The new prices are: Plain wire, 2.15c.; wire nails, base, $2.20; steel pipe, 60 per cent off list; bars, 3.35c.; shapes, 3.60c.; plates, 4.50c. If the various influences mentioned exerted a quieting influence on the steel market the statistical fact is that a carefully kept weighted average shows that from Jan 1, 1915, when the market started advancing, to Dec. 12, 1916, the date of the German peace proposal, there was an average advance in finished steel products of $1.73 per net ton per month, while in the three months Dec. 12 to March 12 there was an average advance of $3.60 per month.

The mills are in a much more completely sold up condition than formerly. There had been a great deal of tonnage placed on books in the form of specific orders, calling for certain deliveries in the future, as the buyers, shipyards, fabricating shops, car and locomotive shops, etc., would be able to fabricate the material. The tonnage obligations on books, as reported by the Steel Corporation, for instance, represented the equivalent of the tonnage that could be produced in a certain number of months, but the tonnages of different classes of materials were quite out of proportion, and the time for which the mills were solidly booked was much less than the average time. The mills were reserving certain tonnages for regular customers. Since the first of the year a great deal of this reserved tonnage has been converted into actual contracts, while distinct promises have been made in other instances, sometimes all details being arranged except the price, whereby the regular consumers are covered in nearly all instances to the close of the year and the mills are booked almost solidly for the period, with all prospects that deliveries will be so behindhand that the tonnage will run far into 1918. In other words, there can be very little additional buying except for 1918.

There is no information as to the volume of steel orders placed or about to be placed by the United States government in its war preparations but the evidence in the market is that the tonnage is crowding the mills. It is to be given every preference desired by the authorities and the prices are understood to have no relation to those now prevailing, or recently prevailing, in the open market.

The traffic congestion on the railroads interfered greatly with production in February. Pig iron production was 10 to 15 per cent below what it should have been, even in February weather, on account of insufficient coke deliveries due chiefly to car shortages in the coke regions, and while steel production was not greatly curtailed by reason of pig iron shortage there was considerable curtailment on account of fuel shortage and inability to ship finished product. A slight improvement in traffic conditions seemed to be promised for March, but on March 4 the heaviest snowfall of the season gave conditions in the Central West a fresh backset, and real recovery is still for the future. While references are usually made to "car shortage" it is not a case of the number of cars but of their position. The variable in the equation determining car supply is the temperature, as affecting the steaming capacity of locomotives, and the hopes of the iron and steel trade must be for the weather to get warm.

PIG IRON

The pig iron markets have been endeavoring to equalize, but with indifferent success. Southern iron has advanced rather sharply and is now generally held at $30, Birmingham, with a limited tonnage available at less. At this level it would not undersell northern iron except in spots. Valley foundry iron, however, seems to have become established at $35, furnace, for second half delivery, with basic still quotable at $30, and an equalization between these grades is needed. Throughout the pig iron market there is a strong advancing tendency.

UNFINISHED STEEL

For early deliveries billets and sheet bars would readily bring $65, the scarcity being even more pronounced, but a new feature in the situation is a distinct indisposition of buyers to interest themselves in forward deliveries. Apparently a theory has been developed that on account of much more steel making than steel finishing capacity being in course of construction unfinished steel is likely to become more plentiful relative to finished products.

Non-Ferrous Metal Market

March 9.—Copper has remained practically unchanged, while tin has advanced in an uncertain market. The Trust price of lead has been advanced again. Spelter has remained firm in a quiet market. Silver has dropped slightly.

Copper.—The copper market for the past two weeks has been dull for the most part, with early deliveries hard to get. Exports in February were 24,937 tons. The Boston News Bureau places the February refinery output at 170,000,000 lb., against 180,000,000 lb. in January. The freight embargoes have curtailed production somewhat. Lake is now held at 36.00 cents with electrolytic at 37.00 cents. Second quarter electrolytic is held at 35.00 cents, third quarter at 32.50 and fourth quarter at 31.00 cents.

Tin.—Around the first of the month there was a fairly good business done in tin and the market advanced from 50.00 cents on Feb. 26 to 54.12½ on March 8, for spot Straits. American deliveries for February were below 4000 tons. On March 1, there were 1852 tons in store, and 1175 tons on dock, according to the American Metal Market. The sailing of steamers is very uncertain and the market is more or less nervous. Recently there has been some fair business in Banca, Australian and Chinese tin.

Lead.—On March 2 the Trust price of lead was advanced to the basis of 9.00 cents New York. Early deliveries remain scarce and the outside market stands from 10.00 to 11.00 cents.

Spelter.—The consuming demand for spelter has been very dull although the market remains firm and practically unchanged at 11.00 cents. There has been some buying by dealers but this has as yet not stimulated the market to any extent.

Other Metals.—Antimony has dropped from 33.00 cents on Feb. 26 to 30.50 cents on March 8, in a dull market. No. 1 Virgin aluminum is quoted at 58.00-60.00 cents. Magnesium is unchanged at $3.00-$3.50, cadmium is $1.50, quicksilver $108.00, platinum $105.00, cobalt $1.70, and silver has dropped from over 77 cents to 75⅜.

Chemical Market

Coal Tar Products.—There has been considerable activity noted in this division of the chemical industry during the fortnight and a number of interesting developments have occurred.

Benzol.—A very firm situation has prevailed throughout the past two weeks. Manufacturers are holding tight and while a few contracts have been made covering deliveries for the next three years these offerings have generally been withdrawn and producers are not now inclined to sell in large quantities for other than deliveries this year.

Toluol.—The situation in this product is even firmer than with benzol. Contracts have been placed at very high levels as compared with those prevailing some few months ago and manufacturers realizing that the situation favors their viewpoint are not inclined to let go of supplies for deliveries covering extended periods. The demand for intermediates from toluol has been quite heavy throughout the interval.

Aniline Oil.—It now seems that the recent advance in this product was due to the purchase of some 200 tons of the material by a large producer who is no longer selling the product but is consuming it in the production of a material that allows of a large margin of manufacturing profit. The situation remains tight and while the production is large prices hold very well indeed with spot offerings greatly restricted.

Diphenylamine.—As a result of quiet buying on the part of both American and Canadian explosive manufacturers, there has been considerable interest shown in this product and important business has been placed at the low price of about 80c. For ordinary average business sellers generally quote 85c.

Carbolic Acid.—In contrast to other firm markets, the *phenol* situation is weak. Manufacturers are quite frank in this statement that they are far from pleased with existing conditions. Some of the large producers admit that considerable stocks remain at plants and are difficult to move. Government buying would strengthen the market, but so far buying of this character has not been important.

Naphthalene.—A very firm situation has prevailed for this product throughout the two weeks. The usual spring demand has been heavier than usual and buyers have found difficulty in securing sizable lots of balls. Price has been higher and very strong.

Creosote Oils.—Scarcity of supplies and a heavy demand from consuming sources have created a firmer situation in this line than has prevailed for some time past.

New Developments.—Hardly a day passes without announcements of new developments in the intermediate trade. During the past fortnight new productions of meta-nitraniline, meta-phenylenediamine, paranitraniline, malachite green, cinnamic acid, synthetic, and other products were announced.

Heavy Chemicals.—A heavy local business in heavy chemicals has passed since we last reported. This is due to an increased consuming demand and the fact that buyers have been forced into the market for their immediate needs owing to the failure of the railroads to deliver material ordered months ago.

Brimstone.—Producers advanced their price to the level of $45, stating that this was due to the difficulty of securing transportation facilities. This situation, of course, reflects in the market for brimstone sulphuric acid which has strengthened to a marked degree with a large movement noted at Eastern points. Spot lots of acid have been remarkably low throughout the interval. Pyrites acid has, in sympathy, shown considerable firmness.

Nitrate of Soda.—The ocean-freight situation has created the highest market that has prevailed since the abnormal rise of a year ago. It is rumored that the government will in the event of hostilities take over the nitrate business. The firmness of the crude material finds reflection in the *nitric acid* situation which is from 25 per cent to 50 per cent higher than two weeks ago. *Bichromate of potash* has eased off under pressure of offers from a new producer. *Bichromate soda* has been quiet with prices low. There are now eight producers of this product. *Quicksilver* has been easier because of arrivals from the Coast and Mexico and the lack of consuming demand due to recent high prices. *Soda ash* has been in free movement. The railroad embargoes have forced some buyers into the open market. Nineteen hundred and eighteen business is improving. One of the large manufacturers has recently been in the market to cover requirements. *Caustic soda* is higher and there has been heavy buying because of non-delivery of contracts. For late 1917 and 1918 contracts have been higher. *Bleaching powder* in domestic drums has been freely offered. Contracts have been placed at low prices. Owing to export restrictions, export drums have been offered somewhat more freely. *Epsom salts'* manufacturers have advanced their prices and owing to the difficulty of getting supplies from the Orient, spot lots of the salt have been very light.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 8, 1917

Acetone, Drums	lb.	.23 —	.23½
Acid, acetic, 28 per cent	lb.	.03½ —	.04
Acetic, 56 per cent	lb.	.08 —	.09
Acetic, glacial, 99½ per cent carboys	lb.	.24 —	.25
Boric, crystals	lb.	.10½ —	.12
Citric, crystals	lb.	.71 —	.72
Hydrochloric, commercial, 18 deg.	lb.	.01¾ —	.01½
Hydrochloric, 20 deg.	lb.	.01½ —	.01¾
Hydrochloric, C. P., conc., 22 deg.	lb.	.01¾ —	.02
Hydrofluoric, 30 per cent, in barrels	lb.	.04¾ —	.05
Lactic, 44 per cent	lb.	.11 —	.12
Lactic, 22 per cent	lb.	.04½ —	.04½
Nitric, 36 deg.	lb.	.05 —	.05½
Nitric, 42 deg.	lb.	.06½ —	.08
Oxalic, crystals	lb.	.45½ —	.46
Phosphoric, 85 per cent	lb.	.27 —	.29
Picric	lb.	.70 —	.75
Pyrogallic, resublimed	lb.	3.50 —	4.00
Sulphuric, 60 deg.	ton	17.00 —	20.00
Sulphuric, 66 deg.	ton	28.00 —	30.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00 —	40.00
Tannic, U. S. P., bulk	lb.	.45 —	.50
Tartaric, crystals	lb.	.82½ —	.83
Alcohol, grain, 188 proof	gal.	2.72 —	2.74
Alcohol, Wood, 95 per cent	gal.	1.00 —	1.02
Alcohol, Denatured, 180 proof	gal.	.66 —	.67
Alum, ammonia lump	lb.	.04 —	.04¼
Alum, chrome ammonium	lb.	.18½ —	.19½
Alum, chrome potassium	lb.	.30 —	.35
Alum, chrome sodium	lb.	.20 —	.22
Alum, potash lump	lb.	.05½ —	.05½
Aluminium Sulphate, technical	lb.	.01¾ —	.02
Aluminium Sulphate, iron free	lb.	.03½ —	.03½
Ammonia aqua, 26 deg. carboys	lb.	.05½ —	.05¾
Ammonium carbonate	lb.	.10 —	.11
Ammonium nitrate	lb.	.14 —	.14½

Ammonium, sulphate, domestic	lb.	.04⅞—	.05
Amyl acetate	gal.	4.00 —	4.25
Arsenic, white	lb.	.11½—	.12
Arsenic, red	lb.	.25 —	.60
Barium chloride	ton	90.00 —	95.00
Barium sulphate (Blanc Fixe), powder	lb.	.04 —	.04¼
Barium nitrate	lb.	.11 —	.11½
Barium peroxide, basis 70 per cent	lb.	.27 —	.30
Bleaching powder, 35 per cent, chlorine, domestic, drums	lb.	.03¼—	.03½
Borax, crystals, sacks	lb.	.07 —	.07¼
Brimstone, crude	ton	45.00 —	...
Bromine, technical	lb.	1.30 —	1.35
Calcium, acetate, crude	lb.	.03 —	.03½
Calcium, carbide	ton	80.00 —	90.00
Calcium chloride, 76-15 per cent, fused, lump,	ton	26.00 —	30.00
Calcium peroxide	lb.	1.70 —	1.75
Calcium phosphate	lb.	.30 —	.32
Calcium sulphate	lb.	.01 —	.01½
Carbon bisulphide	lb.	.04 —	.04½
Carbon tetrachloride, drums	lb.	.16 —	.17
Caustic potash, 82-92 per cent	lb.	.78 —	.80
Caustic soda, 75 per cent	100 lb.	4.25 —	4.30
Chlorine, liquid	lb.	.15 —	.16
Cobalt sulfate	lb.	... —	...
Copperas	100 lb.	1.00 —	1.15
Copper carbonate	lb.	.33 —	.35
Copper cyanide	lb.	.70 —	...
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.43 —	.43½
Epsom salt, bags	100 lb.	3.25 —	3.75
Formaldehyde, 40 per cent	lb.	.12⅝—	.13
Glauber's salt	100 lb.	.65 —	.70
Glycerine, bulk, C. P.	lb.	.54 —	.55
Iodine, resublimed	lb.	3.50 —	3.55
Iron oxide	lb.	.02 —	.08
Lead acetate, white crystals	lb.	.14 —	.14½
Lead arsenate	lb.	.10 —	.10¼
Lead nitrate	lb.	.16¾—	.17
Litharge, American	lb.	.08½—	.09½
Lithium carbonate	lb.	1.02 —	1.03
Manganese dioxide	lb.	.60 —	.65
Magnesium carbonate, U. S. P.	lb.	.24 —	.27
Nickel salt, single	lb.	.14 —	.14½
Nickel salt, double	lb.	.11 —	.11½
Phosphorus, red	lb.	1.15 —	1.20
Phosphorus, yellow	lb.	.85 —	.90
Potassium bichromate	lb.	.36 —	.38
Potassium bromide, granular	lb.	1.00 —	1.01
Potassium carbonate, calcined, 80-85 per cent	lb.	.35 —	.45
Potassium chlorate, crystals	lb.	.62 —	.63
Potassium cyanide, 98-99 per cent	lb.	1.90 —	2.00
Potassium iodide	lb.	2.90 —	2.92
Potassium muriate, 80-85 per cent basis of 80 per cent	ton	415.00 —	425.00
Potassium nitrate	lb.	.30 —	.32
Potassium permanganate	lb.	3.50 —	3.60
Potassium prussiate, red	lb.	2.50 —	2.75
Potassium prussiate, yellow	lb.	.90 —	.91
Potassium sulphate, 90-95 per cent basis 90 per cent	ton	325.00 —	350.00
Rochelle Salts	lb.	.36½—	.37
Sal ammoniac, gray gran	lb.	.10 —	.12
Sal ammoniac, white gran	lb.	.18 —	.19
Sal soda	100 lb.	1.10 —	1.20
Salt cake	100 lb.	.95 —	1.05
Silver cyanide	oz.	.70 —	...
Silver nitrate	oz.	.47¾—	...
Soda ash, 58 per cent, light, flat	lb.	.03 —	.03⅛
Soda ash, 58 per cent, dense, flat	lb.	.035 —	.036
Sodium acetate	lb.	.09 —	.10
Sodium benzoate	lb.	7.00 —	7.50
Sodium bicarbonate, domestic	100 lb.	1.85 —	1.95
Sodium bicarbonate, English	lb.	.03 —	.03⅛
Sodium bichromate	lb.	.16 —	.16½
Sodium bisulphite, powd	lb.	.04½—	.05
Sodium chlorate	lb.	.25 —	.27
Sodium cyanide	lb.	1.20 —	1.30
Sodium fluoride, commercial	lb.	.11¾—	.12½
Sodium hyposulphite	lb.	.01½—	.02
Sodium nitrate, refined	lb.	.05½—	.05¾
Sodium nitrite	lb.	.11 —	.12
Sodium peroxide	lb.	1.00 —	1.15
Sodium phosphate (tri)	lb.	.04½—	.04¾
Sodium prussiate, yellow	lb.	.31 —	.32
Sodium silicate, liquid	100 lb.	1.25 —	1.30
Sodium sulphide, 30 per cent, crystals	lb.	.03 —	.03¼
Sodium sulphide, 60 per cent, fused	lb.	.02½—	.03
Sodium sulphite	lb.	.03¼—	.03½
Strontium nitrate	lb.	.25 —	.28
Sulphur chloride, drums	lb.	.09¾—	...
Sulphur, dioxide, liquid, in cylinders	lb.	.11½—	...
Sulphur, flowers, sublimed	100 lb.	2.55 —	2.60
Sulphur, roll	100 lb.	2.15 —	2.20
Sulphur, crude	ton	45.00 —	46.00
Tin bichloride, 50 deg	lb.	.13½—	.13¾
Tin oxide	lb.	.54 —	.54½
Zinc carbonate	lb.	.24 —	.26
Zinc chloride	lb.	.15 —	.15½
Zinc cyanide	lb.	.50 —	...
Zinc dust	lb.	.20 —	.21
Zinc oxide, American process XX	lb.	.11½—	.12
Zinc sulphate	lb.	.06½—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.57 —	.58
Benzol, 90 per cent	gal.	.53 —	.54
Toluol, pure water white	gal.	1.80 —	1.90
Xylol, pure, water white	gal.	.60 —	1.00
Solvent naphtha, water white	gal.	.22 —	.24
Solvent naphtha, crude heavy	gal.	.16 —	.18
Creosote oil, 25 per cent	gal.	.26 —	.29
Dip oil, 20 per cent	gal.	.23 —	.25
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	.95 —	1.00
Carbolic acid, crude, 50 per cent	lb.	.55 —	.60
Carbolic acid, crude, 25 per cent	lb.	.28 —	.30
Cresol, U. S. P.	lb.	.19 —	.20

Intermediates, Etc.

Alpha naphthylamine	lb.	1.00 —	1.25
Aniline oil	lb.	.27½—	.29
Aniline salts	lb.	.28 —	.31
Anthracene, 80 per cent	lb.	.10 —	...
Benzaldehyde	lb.	4.00 —	4.50
Benzidine, base	lb.	1.65 —	1.80
Benzoic acid	lb.	7.75 —	8.50
Beta Naphthol, sublimed	lb.	.80 —	.85
Dichlor benzol	lb.	.48 —	.50
Dimethylaniline	lb.	.56 —	.60
Diphenylamine	lb.	.85 —	.90
H-Acid	lb.	Nominal	
Metaphenylenediamine	lb.	1.25 —	1.50
Monochlorbenzol	lb.	.34 —	.35
Naphthalene, flake	lb.	.09½—	.09¾
Naphthionic acid	lb.	1.75 —	2.00
Nitro naphthalin	lb.	.45 —	.50
Ortho-amidophenol	lb.	... —	...
Ortho-toluidine	lb.	1.20 —	1.25
Para-amidophenol, base	lb.	4.25 —	4.50
Paranitraniline	lb.	1.20 —	1.30
Paraphenylenediamine	lb.	3.50 —	3.75
Para toluidine	lb.	1.75 —	2.00
Phenol, U. S. P.	lb.	.42½—	.45
Resorcin, technical	lb.	9.00 —	...
Resorcin, pure	lb.	17.00 —	18.00
Salicylic acid	lb.	.75 —	.80
Salol	lb.	1.35 —	1.50
Sulphanilic acid	lb.	.30 —	.32
Tolidin	lb.	3.00 —	...
Toluidine-mixture	lb.	.90 —	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.05 —	...
Corning, Ohio	bbl.	2.38 —	...
Somerset, Ky.	bbl.	2.18 —	...
Wooster, Ohio	bbl.	2.05 —	...
Indiana	bbl.	1.73 —	...
Illinois	bbl.	1.87 —	...
Oklahoma and Kansas	bbl.	1.70 —	...
Caddo, La., light	bbl.	1.70 —	...
Corsicanna, Tex., light	bbl.	1.70 —	...
California	bbl.	.73 —	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½—	.14
Cylinder, light	gal.	.21 —	.26
Cylinder, dark	gal.	.18 —	.19
Extra cold test	gal.	.26 —	.31
Paraffine, high viscosity	gal.	.29½—	.30
Paraffine, .903 sp. gr.	gal.	.21½—	.22
Paraffine, .865 sp. gr.	gal.	.18½—	.19

Flotation Oils

Pine oil, steam distilled	gal.	.59 —	...
Pine oil, destructively distilled	gal.	.47 —	...
Pine-tar oil	gal.	.19 —	...
Pine-tar oil, double refined	gal.	.30 —	...
Pine oil, light	gal.	.37 —	...
Pine oil, heavy	gal.	.26 —	...
Pine tar, thin	gal.	.18 —	...
Turpentine, crude	gal.	.38 —	...
Hardwood oil, f.o.b. Michigan	gal.	.16 —	...
Creosote, coal tar neutral	gal.	.15 —	...
Creosote, coal tar, acid	gal.	.21 —	...

Vegetable and Other Oils

China wood oil	gal.	.13½—	.15
Cottonseed oil, crude	gal.	.86 —	...
Linseed oil, raw, cars	gal.	.93 —	...
Peanut oil, crude	gal.	1.00 —	...
Rosin, 280 lb.	bbl.	6.00 —	...
Rosin oil, first run	gal.	.38 —	...
Rosin oil, fourth run	gal.	.70 —	...
Soya bean oil, Manchuria	gal.	.13 —	...
Turpentine, spirits	gal.	.51 —	...

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00 —	40.00
Barytes, floated, white, domestic	ton	25.00 —	35.00
Beeswax, white pure	lb.	.52 —	...
Carnauba wax, highest grade	lb.	.51 —	...
Chalk, light, precipitated, English	lb.	.03 —	.06
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	.80 —	1.05
Red lead, dry, carloads	lb.	.10½—	...
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	10.00 —	13.00
White lead, dry	lb.	.09¼—	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	120.00 —	130.00
Chrome cement, Grecian	net ton	80.00 —	90.00
Clay brick, 1st quality firecl ay	per 1000	40.00 —	50.00
Magnesite, Grecian, dead burned	net ton	85.00 —	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00 —	140.00
Silica brick	per 1000	40.00 —	45.00

Ferroalloys

Ferro-carbon-titanium, carloads	lb.	.12½—	...
Ferrochromium	lb.	Nominal	
Ferromanganese, domestic, delivered	ton	250.00 —	300.00
Ferromanganese, English	ton	185.00 —	...
Ferromolybdenum, per lb. of Mo	lb.	4.00 —	...
Ferrosilicon, 50 per cent carloads del. Pittsburgh	ton	200.00 —	250.00
Ferrosilicon, 50 per cent, contract	ton	100.00 —	...
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	1.95 —	...
Ferrovanadium, f.o.b. works	lb.	2.75 —	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

The Agricultural Development Company, incorporated under the laws of Maine, plans to manufacture a fertilizer that will contain almost 2 per cent of potash. This is to be done by utilizing the vast deposits of mussel beds on the Maine coast.

Alcohol Products Co., Newark, N. J., has been incorporated with a capital of $650,000 to manufacture and deal in anhydrous and aqua-ammonia and chemicals. The incorporators are H. T. Edgar, H. M. Miner, Brooklyn; H. W. Haines, Milburn.

Alaska Sulphur Co., Minneapolis, Minn., has been incorporated with a capital of $500,000.

Alaska Yukon Copper Co., Inc., New York, has been incorporated with a capital of $100,000. The incorporators are K. Wein, A. Moessner and Clemens Ruttinger of Brooklyn.

Bleaco Chemical Co., Mayfield, La., has been incorporated with a capital of $5,000. The incorporators are W. J. Johnston, E. L. Johnson and J. J. Radford.

Booth Chemical Co., Jersey City, N. J., has been incorporated with a capital of $100,000. The incorporators are L. M. Booth, Plainfield; W. H. P. Fisher, Jersey City; Arthur J. Donniez, Brooklyn.

Bronzo Alumina Corp., Tonawanda, N. Y., has been incorporated with a capital of $16,000 to deal in aluminum, silicon, bronze, iron castings. The incorporators are F. A. Redner, J. E. Kaufman, J. H. Willing, 141 Masten Street, Buffalo.

Buffalo Chemical and Oil Co., Buffalo, N. Y., has been incorporated with a capital of $5,000 to deal in chemicals and dyestuffs. The incorporators are N. P. Hoff, F. B. Steele, 183 S. James Place, Buffalo.

The Burnwell Mining Company, Dayton, Ohio, has been incorporated with a capital of $100,000. The incorporators are Charles Dunn and S. B. Chilton.

California Aniline and Chemical Co., San Francisco, Cal., has been incorporated with a capital of $50,000 to manufacture aniline dyes and chemicals. The incorporators are E. L. Hueter, H. P. Roach, L. H. Lewars, B. R. Bowron, E. C. Hueter.

Central Market Paper Co., Columbus, Ohio, has been incorporated with a capital of $50,000. The incorporators are S. Ornstein, L. L. Goldberg, W. Painter, A. H. Journey, E. F. Schanfarber.

The Central Foundry Company, Portland, Me., has certified an increase in its capital stock from $8,200,000 to $8,800,000.

Centric Metal Co., Inc., New York, has been incorporated with a capital of $25,000 to buy and sell minerals and by-products. The incorporators are L. Heppenheimer, J. and M. Krulan, 1102 President St., Brooklyn.

The Cooney Extracting Company of Atlantic City, N. J., has been chartered with $100,000 to extract cotton from mixed cottons and woolens and manufacture chemicals and textiles by Charles P. Tilton, Charles H. Parsons and Sadie A. Burris, all of Atlantic City, N. J.

The De Vore Chemical Co., 196 North 21st Street, Columbus, Ohio, has been incorporated with a capital of $50,000 to manufacture chemicals. The incorporators are P. R. De Vore, P. F. Wilkinson, C. E. Williams, W. C. Shacklett and J. F. Waddy.

Empire Refineries, Inc., Augusta, Me., has been incorporated with a capital of $5,000,000 to deal in gas, oil and other mineral bearing properties.

Empire State Zinc & Copper Co., Dover, Del., has been incorporated with a capital of $1,000,000 to mine copper, gold, silver, etc. M. M. Hirons, J. B. Bailey, Dover, Del., incorporators.

Esperanza Mining Co., New York, has been incorporated with a capital of $2,000,000 to do a general mining, milling and refining business. The incorporators are A. W. Britter, S. B. Howard, L. H. Gunther, all of New York.

The capital stock of the Francis Chemical Company of Providence, R. I., has been increased from $40,000 to $100,000, according to an amendment made to the articles of association on the State charter.

Gabriel & Schall, Inc., Manhattan, has been incorporated with a capital of $100,000 to conduct a chemical business. The incorporators are H. Schall, L. Gabriel, S. H. F. Schall, 205 Pearl Street, New York City.

Garrett Foundry, Inc., New York, has been incorporated with a capital of $53,500 to deal in iron, steel, manganese, foundries, machines. The incorporators are C. H. Fowler, A. W. Trotter, J. C. Garrett, 43 McDonough Street, Brooklyn.

The Gas Products Co., Muskogee, Tex., has been incorporated with a capital of $5,000. The incorporators are R. R. Owen, Muskogee; H. Roschach, Muskogee; E. Roschach, Muskogee.

Gasoline Producing Corp., Wilmington, Del., has been incorporated with a capital of $1,000,000 to deal with a process of compressing gasoline oils from casing and head gas.

Gas and Coke Oven Corp., New York, has been incorporated with a capital of $105,000 to deal in coke ovens, stamp mills, smelting machinery, mine coal, oil, gas, construction. The incorporators are M. McEnany, L. M. Woodworth, G. H. Rowe, Jr., 122 Milton Street, Brooklyn.

The General Roofing Manufacturing Company announces the company has purchased the Mound City Paint & Color Co. and the Gregg Varnish Co., both of St. Louis, and the Lockport Paper Co. mill at Niagara Falls, N. Y., and that a new corporation has been organized, to be known as the Certain-teed Products Corporation. In the new company's formation there will be issued $3,500,000 first preferred 7 per cent cumulative stock, $1,925,000 second preferred 7 per cent cumulative convertible stock and 60,000 shares of common stock. Headquarters will remain in St. Louis. The increased capital available under the new organization will be used in extending the business of the roofing company. The large mills in East St. Louis and Marseilles, Ill.; York, Pa., and Richmond, Cal., will be enlarged and improved. The paper mill at Niagara Falls also will be enlarged and a roofing factory will be built adjoining it. The company will enter in an aggressive manner the paint and varnish field on a big scale, and it was because of this plan the Mound City and Gregg companies were taken over.

Gills Glass Co., Millbrook, N. Y., has been incorporated with a capital of $300,000 to manufacture glass, glassware, electric light goods, molds, stools. The incorporators are J. F. Fitzharris, E. C. Wilson, F. D. Gill, East York and Thompson Streets, Philadelphia, Pa.

Great Lakes Chemical Co., Cleveland, Ohio, has been incorporated with a capital of $25,000. The incorporators are Esther L. Jay, A. Akers, Edithe L. Akers and H. S. Jay.

Charles A. Henderson Chemical Co., Inc., Anderson, Ind., has been incorporated with a capital of $10,000 to deal in chemicals, patent medicines and stock food remedies. The incorporators are W. D. Kimball, H. R. Hayes and N. M. McCullough.

K. F. G. Products Co., New York, has been incorporated with a capital of $10,000 to deal in chemicals, dyestuffs, ores, compounds, paints, drugs. The incorporators are S. Greenberg, I. Lowenbraun, B. L. Karliner, 116 Nassau Street.

Kerr Glass Manufacturing Company, Portland; capitalization increased from $250,000 to $500,000. Samuel C. Kerr, president; A. T. W. Kerr, secretary.

Mansfield Paint Co., Mansfield, Pa., has been incorporated with a capital of $150,000 to manufacture all kinds of paints, stains, etc. The incorporators are C. H. Ranck, Mansfield, Pa.; D. D. Buck, George W. Dillman, all of Wilmington, Del.

The Mineral Paint Zinc Corporation of Newark, N. J., has increased its capital from $400,000 to $5,000,000. August Roche, Jr., is the agent.

The Montana Bingham Consolidated Mining Company voted for the increase of the capital stock to $3,000,000. It is an increase from 1,500,000 shares of $1 par value to 3,000,000 shares of $1 par value, or $3,000,000 capitalization. It is stated that the entire increase of 1,500,000 shares will go into the treasury for the purpose of financing the proposition. The fund to be raised will be devoted to the development of the big Bingham domain on large lines. The company owns 170 acres of mineral ground and has a fifth interest in the adjoining Bingham Amalgamated, which embraces 360 acres. It is reported that a fund of $200,000 cash has been guaranteed for a block of the treasury stock, and that probably ultimately a mill will be built at Bingham for the reduction of the second-class ores. The company has one development tunnel 4,85 feet in length and other workings.

The National Aniline & Chemical Company of New York City has filed application to establish offices in Charlotte, N. C.

National Envelope Co., Kittery, Me., has been incorporated with a capital of $300,000 to manufacture all sorts of paper goods, general printing, publishing.

National Potash Corp., Rochester, N. Y., has been incorporated with a capital of $25,000 to manufacture potash, chemicals, soaps, etc. The incorporators are H. N. Dons, W. A. Delongue, T. J. Morrison, Rochester.

Pacific Steel & Copper Plate Co., San Francisco, Cal., has been incorporated with a capital of $25,000 to deal in iron, copper, zinc and similar materials. The incorporators are G. R. Reed, C. M. Reed, A. A. Taft, V. J. De Mamiel, G. R. Reed, Jr.

Pan-American Leather Co., Middletown, has been incorporated with a capital of $15,000 to manufacture leather and hides.

Pendennis Metals Corp., New York, has been incorporated with a capital of $10,000 to do mining, milling, smelting. The incorporators are P. W. McQuillen, W. G. Wiechmann, E. H. Green, 49 Wall Street.

Petroleum Light & Heat Co., Wilmington, Del., has been incorporated with a capital of $50,000 to manufacture and produce petroleum, etc. Incorporators are M. L. Rogers, L. A. Irwin, H. W. Davis, all of Wilmington, Del.

Philadelphia Metal Drying Form Co., Philadelphia, Pa., has been incorporated to manufacture machinery. The incorporators are H. E. Latter, N. P. Coffin, Wilmington, Del.; C. M. Egner, Elkton, Md.

Pittsburg-Utah Potash Fertilizer Co., Wilmington, Del., has been incorporated with a capital of $500,000 to carry on the business of chemists and chemical manufacturers. The incorporators are F. D. Buck, George W. Dillman, M. L. Horty, local Wilmington incorporators.

The Quaker Valley Refining Co., Pittsburgh, Pa., has been incorporated with a capital of $100,000. The incorporators are H. J. Hackel, Pittsburgh; A. E. Nesbit, F. R. Nesbit, both of Coraopolis, Pa.

The Regent Brass Foundry Co., Marysville, Ohio, has been incorporated with a capital of $30,000. The incorporators are J. Klein, A. V. Birnbaum, A. J. Hale, S. M. Davis and E. Weinberger.

The Rye Patch Mining Co., Ogden, Utah, has been incorporated with a capital of $1,000,000. The incorporators are F. G. Taylor, L. R. Eccles, J. M. Eccles, J. B. Devine, W. H. Petty, J. Scowcroft of Ogden, S. A. Greenwood and C. D. Day of Salt Lake.

Silver Queen Mining Co., Erie, Pa., has been incorporated with a capital of $100,000. Rachel I. Darwin, Harry P. Morrid, George W. Bogart and Ida M. Darwin, all of Erie, Pa., are the incorporators.

The South Penn Oil Co. stockholders have voted to increase the capital from $12,500,000 to $20,000,000. The new stock is to be issued as a 60 per cent stock dividend to holders of record.

Southern Carbon Co., Wilmington, Del., has been incorporated with a capital of $150,000 to manufacture, buy, sell and deal in and with gas carbon, etc. The incorporators are H. E. Latter, N. P. Coffin, H. T. Farrow, all of Wilmington.

Square Deal Foundry Corp., Greenwich, Conn., has been incorporated with a capital of $5,000. The incorporators are H. J. Oarr, H. Oarr, Jr., K. Oarr, all of Greenwich.

Standard Oil Co., Louisville, increases capital from $3,000,000 to $6,000,000.

The Standard Steel Corp., Milwaukee, Wis., has been incorporated with a capital of $50,000 to manufacture farm equipments. The incorporators are E. J. DeGunther, David V. Jennings, Jos. P. Kalt, Jr., and E. J. Caster.

Sweetser & Bainbridge, Inc., Albany County, has been incorporated with a capital of $16,000 to manufacture and deal in copper, sulphate, by-products of copper, steel, iron. The incorporators are E. F. Bainbridge, H. G. Batcheller, S. P. Sweetser, Slingerlands.

H. D. Thatcher & Co., Potsdam, N. Y., has been incorporated with a capital of $50,000 to deal in paper, lumber and wood products and novelties and manufacturing baking powder. The incorporators are R. H. Byrns, F. L. Dewey, I. H. Kendall, Potsdam.

Transatlantic Paper Co., Inc., New York, has been incorporated with a capital of $25,000. The incorporators are J. C. Macre, H. Pressprich, 256 79th St., Brooklyn.

United Wool Stock Co., Inc., Manhattan, has been incorporated with a capital of $25,000 to deal in clothes, paper, metals, etc. The incorporators are D. Savetsky,

1255 Franklin Ave.; M. Sheftman, 1325 Franklin Ave.; J. Neumark, 1330 Franklin Avenue, Bronx.

Vermont Feldspar Co., Portland, Me., has been incorporated with a capital of $200,000 to do general quarrying, mining, milling, preparing for market, etc., all kinds of metals, ores, etc.

The Wadsworth Foundry Co., Wadsworth, Ohio, has been incorporated with a capital of $15,000. The incorporators are W. F. Ries, W. A. Helmick, C. C. Patterson, T. J. O'Brien, Joseph Burgess and others.

Walker Foundry & Machine Co., Pittsburgh, Pa., has been incorporated with a capital of $100,000 to manufacture machinery of all kinds.

Washington Pulp & Paper Corp., Richmond, Va., has been incorporated with a capital of $4,000,000. The incorporators are A. J. Hennings, Maywood, Ill.; B. Thomas, Wilmette, Ill.

The Wheeling Steel & Iron Co. of Wheeling, W. Va., at its recent annual meeting, voted to increase the capital stock from $7,500,000 to $10,000,000. This increase of capital stock was made necessary because of the recent declaration of 20 per cent stock dividend by the company. By a unanimous vote of the stockholders also re-elected the old board of directors and adopted a resolution making the annual meeting date the fourth instead of second Tuesday in February. The old directors re-elected are: Isaac M. Scott, C. R. Hubbard, John Duncan, J. J. Holloway, B. W. Peterson, H. H. Hornbrook, W. A. Isett, E. C. Ewing, William F. Stifel, Edward Hazlett and E. W. Oglebay. The annual report showed that the company had a splendid year, with plants running as near capacity as conditions would permit, despite the fact that none of the company's products were used in the manufacture of munitions.

Construction and Operation

California

LOS ANGELES.—The Union Oil Company of California has purchased 3,000,000 barrels of oil from the E. I. Doheny properties in Mexico, and will withdraw six of its big tankers from California-Chilean service for the purpose of transporting the Mexican product through the Panama Canal and thence to Chile.

RIVERSIDE.—The Riverside Portland Cement Company will have a new plant in operation March 1. The company has installed electrical precipitation for removing the dust. This will be treated for its potash contents in a separate plant by a process worked out by the company chemists.

Colorado

DENVER.—The Barrett Company has contracted for the production of the by-product coke department of the Colorado Fuel and Iron Company. The Colorado Fuel and Iron Company has closed a contract with the H. Koppers Co. for the construction of a benzol plant to be used in connection with its coke ovens.

Delaware

WILMINGTON.—The Pusey-Jones Company has taken out permits for two new buildings to cost about $100,000. The company manufactures paper-making machinery.

District of Columbia

WASHINGTON.—The Wayland Oil Company announced in its recent annual report that the company proposes to install a plant to extract gasoline from the natural gas which it produces. The new plant which will soon be ready for operation will add materially to the company's income.

WASHINGTON.—The Bureau of Mines contemplates the erection of a shale retort of the Del Monte type in the Navy Yard, Washington, D. C., to study the production of oil from shale. If the results justify further investigation the Bureau of Mines will probably erect a large retort with the capacity of possibly 500 gallons at either the station at San Francisco or Pittsburgh.

Illinois

CHICAGO.—H. Kramer Co. will erect a smelting plant on West 21st Place to cost $60,000.

PEORIA.—The Globe Manufacturing Company will locate a paint factory here to meet the increasing demand for its products. The company manufactures paints, enamel, varnishes, stains, etc., and has had a small plant in East Peoria.

Indiana

MUNCIE.—The Owens Glass Company, of Toledo, Ohio, has purchased the plant of the Greenfield Bottle Works. Additions will be made and new machines installed for manufacturing bottles.

Iowa

CLINTON.—The Klein Paper Company of Clinton will construct a new paper mill with a capacity three times that of the present plant.

DAVENPORT.—A formal application for the location of the government nitrate plant on the Mississippi River near Rock Island arsenal has been sent to Washington by the mayors of Davenport, Rock Island, Moline, Bettendorf, East Moline and Silvis, and also 30 members of a committee in charge. A report of H. S. Putnam of New York City, consulting engineer, also accompanied the application.

DES MOINES.—The Carpenter Paper Company will erect a plant at 7th and Vine Streets, to cost $80,000.

Louisiana

PLAQUEMINE.—The Southern Oil Refining Company will erect a $50,000 plant five miles from this place. The present capacity will be 500 barrels a day of petroleum products.

Massachusetts

TURNERS FALLS.—The lower plant of the International Paper Company, formerly known as the Turners Falls Paper Company has been purchased by the Keith Paper Company of Greenfield, Mass.

WEST WAREHAM.—A new rolling mill will be installed at the steel plant here. A new furnace is at present being built.

Michigan

WINDSOR.—A site of one and a half acres in the Windsor factory district has been purchased by Samuel Harris, of Galt, Ont., and Max Goldman, of Chicago, who intend to erect a brass-melting foundry.

Missouri

ST. LOUIS.—The Roxana Petroleum Company of Tulsa, Okla., has planned for the erection of a $10,000,000 oil refinery in the East Carondelet district. The Roxana Company is a branch of the Dutch-Shell Corporation, which has extensive plants also in South America.

Nebraska

ALLIANCE.—The American Potash Company will erect a large addition to its present plant and install considerable new machinery. Activity in the potash industry in this field continues.

New York

BROOKLYN.—The W. Beckers Aniline and Chemical Works have let the contract for a new one-story brick factory to cost $100,000.

Ohio

BARBERTON.—Mr. W. S. Galehouse of the Galehouse Realty Company is promoting a new chemical company to be incorporated for $100,000. A plant will be erected as soon as a suitable site can be selected.

CLEVELAND.—The River Furnace Company has purchased an acre of ground on East 49th Street adjacent its plant for future plant development.

NILES.—The Grasselli Chemical Company, which is building a plant at Niles for the manufacture of sulphuric acid, has purchased sixty acres of land adjoining its present buildings for future developments.

WARREN.—The General Electric Company has purchased land and will erect an extension to its lamp factory to cost $200,000.

WARREN.—The International Steel Tube & Rolling Mill will erect a new mill at once and later build its own rolling mill on a site of 25 acres in the Hamilton Tract west of the city.

WELLSBURG.—The McInnes foundry, which has been idle for two years, has been purchased by the Tri-State Foundry and Machine Company, of Pittsburgh, Pa. The plant will be enlarged and many improvements added.

Oklahoma

MUSKOGEE.—The Scandinavian Glass Co. will move its factory from Avant to Muskogee on account of the cheap gas offered by that city.

OKLAHOMA.—The Home Refining Company has ordered a large amount of machinery including tanks, stills and agitators, and also 100 tank cars and will commence the erection of a refinery at once. The company recently purchased 85 acres in the Maplewood addition, east of the State Fair grounds. The company was organized last October and has a capital of $250,000. The officers and directors are J. E. Jones, president; C. M. Joiner, vice-president; G. W. Dill, second vice-president; Secretary of State J. L. Lyon, treasurer; J. C. Willingham, secretary; A. D. Lloyd, E. R. Kerby and A. T. Kellogg, directors.

TULSA.—The Alexander Kerr Glass Company will erect several new buildings at its plant in Sand Springs that will practically double the capacity of the plant.

Pennsylvania

CONNELLSVILLE.—The plant of the United States Electric Steel Company is expected to be completed about May 1. The erection of the furnace is expected to start within a few days.

SHARON.—Sharon men from Pittsburgh have obtained a lease on Rattlesnake Swamp in Cool Spring Township, Mercer County, and will erect a plant for converting the peat into fertilizer. Messrs. J. H. Connors and M. D. Hass, both of Pittsburgh, are interested in the proposition.

Rhode Island

LINCOLN.—The Lonsdale Bleachery and Dye Works will install a fuel oil system to take the place of coal in their power house.

Tennessee

KNOXVILLE.—The matter of a co-operative paper mill is being seriously considered by committees of the East Tennessee Press Association and considrable research has been made by the committee in the preparation of data on the high cost of paper and the feasibility of some kind of co-operative establishment.

Texas

AUSTIN.—A company is being organized with a capital of $200,000 for the purpose of manufacturing pulp stock from cotton stalks. It is understood that a demonstration plant will be established near Waco. It is understood that the finished products will be sold to powder makers for making smokeless powder for domestic consumption.

BEAUMONT.—The Texas Steel Company will put up a large plant here with a capacity of 300 tons per day. The limestone will be obtained from a point between San Antonio and Austin. The plant will cost $300,000 and its output will be used in Texas and adjoining states. The company owns ore reserves in several counties in Northeast Texas, and a railroad from the ore field carries the raw material to Beaumont. Coke from Alabama, Pennsylvania, West Virginia and other states can be obtained by way of the Intercoastal Canal.

HOUSTON, TEX.—Cotton Seed Oil Co. of Texas has purchased site and will erect mill near here to cost $100,000, work to begin Mar. 1.

Utah

SALT LAKE CITY.—The National Dye & Chemical Company, a recently organized concern, will shortly commence manufacturing coal tar dyes. The company is at present negotiating for a site and for coal property. The company expects to build a by-product plant. Mr. Ernest F. Bushman is the president and general manager of the company.

Washington

CONCRETE.—The Superior Portland Cement Company is changing the process in its plant from dry to wet. It is building 8 tanks of reinforced concrete, 36 feet high, and also a new substation. D. C. Findlay is engineer in charge.

CONCRETE.—The Washington Portland Cement Company is installing a pulverized fuel plant of 1000 tons capacity. W. O. Witherspoon is the engineer in charge.

LEAVENWORTH.—Large quantities of timber suitable for paper making are located in the vicinity of Leavenworth, within forty or fifty miles. An investigation of this section has been made by the Government Forestry Department and the facts have been disclosed that millions of feet of timber are present suitable for paper making on the various streams in the neighborhood. The timber is accessible so that it can be floated down the stream in the shape of cordwood. There is a vast amount of water power available and a local market for most of the output.

PORT ANGELES.—The Whalen Bros. Pulp Company will build one of the largest pulp mills in the west at this place. Work on the plant is expected to start in the near future.

PORT ANGELES.—The Northern Board and Paper Mills Company has purchased a tract of land bordering the waterfront to be used for a paper and pulp mill to be erected immediately.

SEDRO-WOOLLEY.—The Skagit Steel and Iron Works have just installed a 1-ton Rennerfelt electric furnace for melting up scrap steel, etc. Mr. F. R. Faller is manager, and Mr. N. Axel V. Paulsson, representing Hamilton & Hansell, of 17 Battery Place, New York City, is supervising the installation of the furnaces.

SEDRO-WOOLLEY. — The Washington Steel and Iron Company have commenced work on a new plant for smelting pig-iron. The capacity for the present will be 25 tons per day. The ore will be mined at Hamilton, 13 miles east, and is a magnetite ore running from 40 to 65 per cent iron. Mr. O. P. Moore is manager.

Manufacturers' Notes

REMOVAL OF PITTSBURGH OFFICES.—The Pittsburgh office of the Buffalo Forge Company, Buffalo Steam Pump Company, and Carrier Air Conditioning Company, located for some years in the House Building, will remove April 1 to the New Union Arcade, the office building owned by Mr. H. C. Frick. Mr. H. Lee Moore continues in charge.

INCREASING PRODUCTION OF FUEL BRIQUETS.—According to the Geological Survey the production of fuel briquets in the United States in 1916 was 295,155 net tons, valued at $1,445,662, an increase compared with 1915 of 73,618 tons, or 33 per cent, in quantity, and $409,946, or 40 per cent, in value. The production in 1916 was the greatest recorded, exceeding that of 1914, the previous high record, by 44,520 tons. This increase in the production of fuel briquets in 1916 is attributed to the improvement in trade conditions arising from the unusual demand for coal, and to a greater general appreciation of the value of briquets for use as household fuel. During the last two years the product of many of the plants has been so much improved that it gives off less of the heavy, tarry smoke that domestic consumers have found so objectionable.

STRONTIUM ORE AND SALTS IN 1916.—Most of the strontium ore marketed in 1916 was produced in Arizona and California. The ore mined in the State of Washington was not marketed. The domestic output was equal to about 10 per cent of the ordinary demand, which amounts to 2000 tons, according to the Geological Survey. The British embargo on strontium salts need cause little disquiet among American users, for abundant ore is no doubt available in this country, and American chemists have shown that they can profitably make the salts needed here.

GLASS PLANTS BUSY.—Millville, N. J., is now enjoying an era of the greatest industrial activity and prosperity in her history. Not only is everybody in the city employed who desires work, but the country districts surrounding the city have been searched for help, and sufficient workers have now been secured to keep the manufacturing plants running to their fullest capacity. Almost 4000 glassblowers are now steadily employed, and are making ware for the South and Central American countries as well as domestic trade. The bleacheries and cotton mills of the Millville Manufacturing Company are having an unprecedented run, and work is rapidly progressing on their new bleachery, which will employ 700 hands. The capacity of the Whitall-Tatum Company glass plants, the Millville Bottle Works, the factories of the T. C. Wheaton Glass Company and the furnaces of the International Glass Company have all been greatly increased and are running full blast. The scarcity of small help, which was a great drawback earlier in the season, has been almost entirely overcome. All of the glass firms report many rush orders for ware, a great amount of which is being shipped to South and Central American ports.

OFFICERS AND DIRECTORS OF GENERAL CHEMICAL CO.—The annual meeting of the General Chemical Company was held on Thursday, Feb. 15, at Phillipstown, N. Y. The only business was the re-election of the Board of Directors: George Blumenthal, Everett B. Bragg, Henry W. Chappell, John M. Goetchius, Nelson A. Howard, William M. Johnson, William J. Matheson, James L. Morgan, Lancaster Morgan, William A. Nash, William N. Nichols, W. H. Nichols, Jr., C. W. Nichols, Edward H. Rising, Charles Robinson Smith, Sanford H. Steele and Henry Wigglesworth. The Board of Directors held a meeting the next day, Feb. 16, and re-elected the officers of the previous year as follows: Chairman of the board, William H. Nichols; general counsel, Sanford H. Steele; president, W. H. Nichols, Jr.; vice-president and secretary, James J. Morgan; vice-president, Charles Robinson Smith; vice-president and western manager, Everett B. Bragg; vice-president, John M. Goetchius; vice-president, Nelson A. Howard; treasurer, Lancaster Morgan; assistant treasurer, Clinton S. Lutkins; assistant secretary, Thomas F. Burgess; assistant secretary, F. H. Nichols; and general auditor, Claude F. Wright.

ADDITIONAL BRITISH IMPORT PROHIBITIONS.—The importation of the following goods is prohibited: Boots and shoes of leather and materials used for the manufacture thereof not already prohibited; diatomine and infusorial earth, glass manufactures not already prohibited; incandescent gas mantles, jute, raw leather, dressed and undressed; painters' colors and pigments, photographic apparatus; plated and gilt wares, soya beans.

ANNUAL REPORT OF DU PONT CO.—The annual report of the E. I. du Pont de Nemours Co. contains this interesting announcement: "For 1917 the reduction in prices of military powders and the continued extension of large credits to the purchasers of these powders make it expedient to curtail extraordinary dividend disbursements. Moreover, uncertainty as to industrial conditions after the termination of the war make it advisable to maintain great financial strength. By this means the most unexpected financial storms will be weathered safely and the company will be in position to take advantage of opportunities for investment that may be presented. To this end the treasurer of the company has recommended a dividend that it is believed can be continued without interruption after the war. The present market value of the common stock seems warranted by the company's assets and prospective profits, and is in line with the dividend recommendation. The laboratories, research and development departments of the company have been indispensable in the rapid progress of the last two years and are now actively engaged in the important work of preparation for the necessary changes in the business of the company, for the great factories for the manufacture of military powder may be useless at the end of the European war and the officers of the company are, therefore, bending their efforts to find a means of diverting part of this equipment to other uses. With this end in view, they expect to employ the $60,000,000 of new capital that was authorized in the reorganization of the company in October, 1915. The acquisition of the Arlington Company, manufacturers of 'pyralin,' was recorded in the last annual report. Since then the purchase of a company manufacturing paints and chemicals (Harrison Brothers & Co., of Philadelphia) has been arranged. The development of these lines of industry promise profitable reward and the continued employment of many of our valuable men, whose services might otherwise be lost with the termination of military demands." The gross earnings of the company for 1916 amounted to $318,845,685, being 1130 per cent over the average receipts of the company for 1913 and 1914. The net earnings were $82,107,692.

CYANAMID CO. BUYS PHOSPHATE PROPERTIES.—The American Cyanamid Co. has purchased extensive phosphate properties in Florida. The properties comprise the mines of the Amalgamated Phosphate Company at Brewster, Polk County, and the output will be used for manufacturing a new fertilizer material, containing ammonia and phosphoric acid, which the American corporation will manufacture in the plant it is completing at Linden, N. J., recently purchased from the Ammo-Phos Corporation. The phosphoric acid will be derived from the Florida phosphate rock and the ammonia contents from the cyanamid which the company manufactures at Niagara Falls, Ontario.

INDUSTRIAL ALCOHOL.—The annual report of the United States Industrial Alcohol Company for the year ended Dec. 31, 1916, shows gross earnings of $6,727,042. This is the best showing in the history of the corporation. The sum of $4,336,024 was carried to the surplus, making the total $10,693,826. President Frederic M. Harrison in his report to stockholders says: "Our 1917 has been sold at prices materially entire capacity for the first six months of higher than those prevailing last year, and in the opinion of your board the outlook for the future is promising."

PARIS CHAMBER WANTS AMERICAN CATALOGS.—The American Chamber of Commerce at Paris, with offices at No. 2 Rue Scribe, is establishing a catalog file and desires to receive catalogs from American manufacturers anxious to start or increase business abroad. The chamber makes a proviso, however, that such catalogs as may be sent for its files should not exceed 9 by 12 in. in measurement, as larger publications would not be suitable for its filing system.

AMERICAN POTASH INDUSTRY IN 1916.—Statistics of the American potash industry gathered by the Geological Survey show a great increase in production over 1915. The total production of potash salts and potash products in the United States in 1916 represented about 10,000 tons of potash (K_2O), with a net value at point of shipment of at least $3,500,000, figured at the prevailing selling prices. This is ten times the value of the production reported for 1915, but the figures submitted by many of the producers represent only a start made toward the end of 1916. The production of K_2O reported to date for 1916 may be summarized as follows: Mineral sources—Natural salts or brines, 3850 short tons; alunite and silicate rocks, including furnace dust recoveries, 1900; total mineral, 5750. Organic sources—Kelp, 1,110; pearlash (mostly from hardwood ashes), only 23 producers having reported to date out of a list of 70 establishments said to be producing, 220; miscellaneous industrial wastes, 1750; total organic, 3080; total output, 8830 tons. The largest output has come from the Nebraska alkali lakes, but the natural saline deposits elsewhere are now just beginning to make important contributions. The figures for potash derived from alunite, of which there is only one important producer, are combined with those for available potash in cement-kiln, flue-dust, greensand, and feldspar recoveries, in order not to disclose figures given in confidence. These do not include a considerable quantity of feldspar said to have been mined and prepared for possible use for the sake of the potash it contains. The production of potash from organic sources is about half that from mineral sources. The recovery of potash from pearlash is an old established industry.

DUROLOID PEBBLES.—The Los Angeles Foundry Company is making balls for grinding mills of an iron-manganese alloy, under the name of "duroloid." These balls have already demonstrated their value as a satisfactory substitute for flint pebbles, and are now being cast in a wide range of sizes to meet trade demands. The balls are cast of a mixture of steel and iron, alloyed with manganese, and poured into metal molds in a battery of water-cooled chilled casting machines. By this system economy in production cost is obtained, and chilling in a metal mold increases the wearing quality of the product. The company is also prepared to make castings of this alloy to replace either silex or manganese steel linings in tube mills.

DIRECTORS OF NEW JERSEY ZINC CO.—The New Jersey Zinc Company has elected the following directors: Charles W. Cox, William P. Hardenbergh, August Heckscher, Thomas D. Jones, Edward S. Marston, Edgar Palmer, John J. Riker, Edwin M. Squier, and A. B. Schultz.

LARGE ELECTRIC HOIST FOR JAPAN.—The Nordberg Manufacturing Co., of Milwaukee, Wis., have recently shipped through Mitsui & Co. a large electric hoist for installation at the Ashio Copper Mines of Furukawa & Co., Tokyo, Japan. Furukawa & Co. is the largest mining company in Japan and according to a recent statement have an annual production of: Copper, 38,000 tons; copper ore, 200,000 tons; sulphate of copper, 1500 tons; bare copper wire, 18,000 tons; coal, 3,000,000 tons. The Ashio mines at which the new hoist is to be installed are the largest copper producing group owned by the company. The design of the hoist is in general similar to many other electric hoists built by the Nordberg Manufacturing Co. for installation in the country. The drums are 10 ft. in diameter for 1800 ft. depth. The drive is by motor through cut herringbone gears, power being supplied from a nearby hydroelectric plant.

DE LAVAL OPENS SEATTLE BRANCH.—The De Laval Steam Turbine Company, Trenton, N. J., manufacturers of steam turbines and helical reduction gears for all classes of service, including ship propulsion and marine work, centrifugal pumps, centrifugal compressors and similar apparatus, announces the opening of a district sales office in the Smith Building, Seattle, Wash., in charge of Mr. William Pullen.

NEW OXYGEN PLANT.—The Burdett Oxygen Company will complete the erection of its Salt Lake City plant on March 1, and will be in a position to furnish pure oxygen to users in that territory. This is one of a chain of plants erected by the Burdett Company. The capacity of their Los Angeles plant has recently been increased 50 per cent.

PONY CALCULATING MACHINE.—The Marchant Calculating Machine Co., San Francisco, Cal., has just put on the market its new pony machine. The dimensions of the standard Marchant are 10 by 15 in., or 10 by 18 in., according to the number of digits. The Marchant pony is 8 by 12 in. or 8 x 13½ in., according to the number of digits.